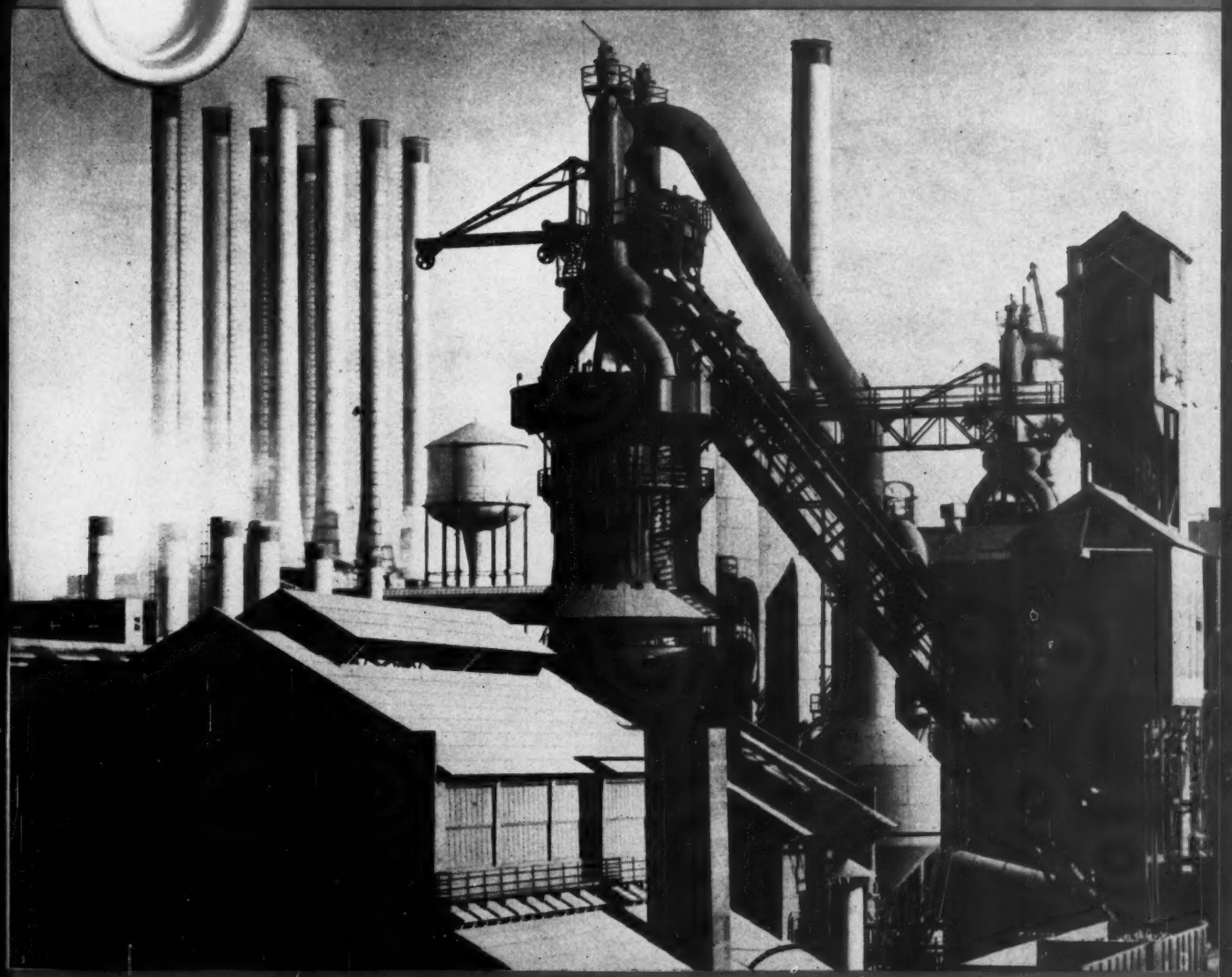
In this issue: STEEL MILL LUBRICATION FROM MANAGEMENT'S POINT OF VIEW

OCTOBER, 1952

Vol. 8, No. 5

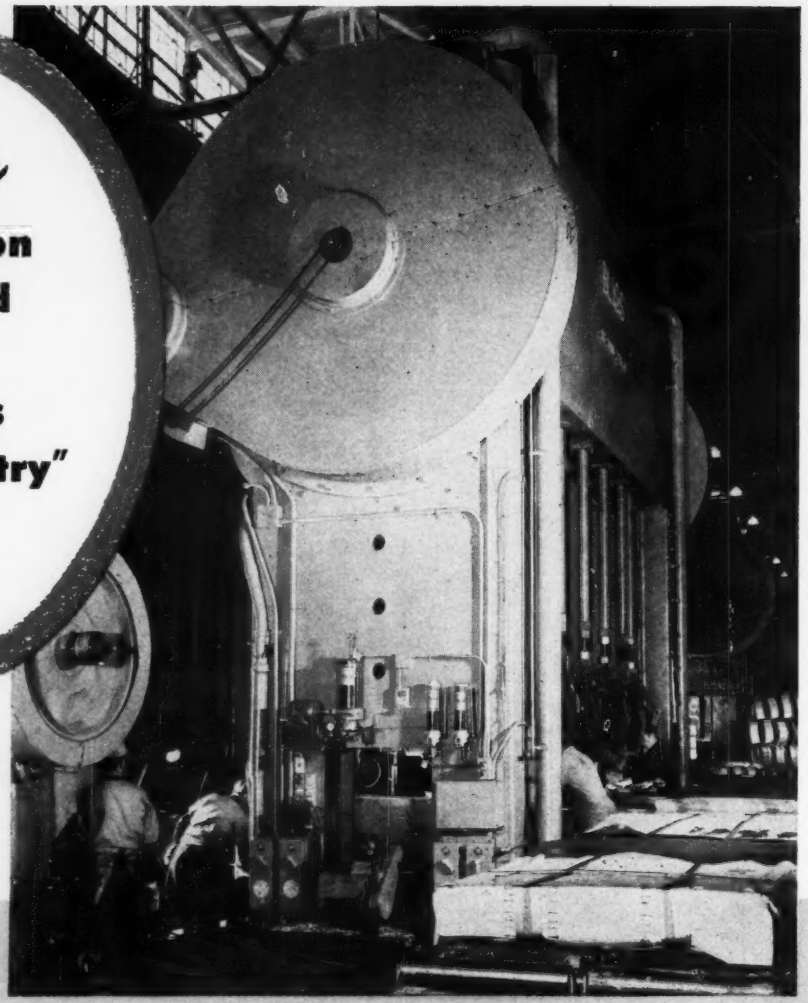
Lubrication ENGINEERING



JOURNAL OF

THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

"Trabon lubrication has saved millions of dollars for industry"



● No machine can operate efficiently without proper lubrication. Trabon Lubricating Systems —which handle both oil and grease on machines of any size—have proved their ability to do a good job for industry during 21 years of service.

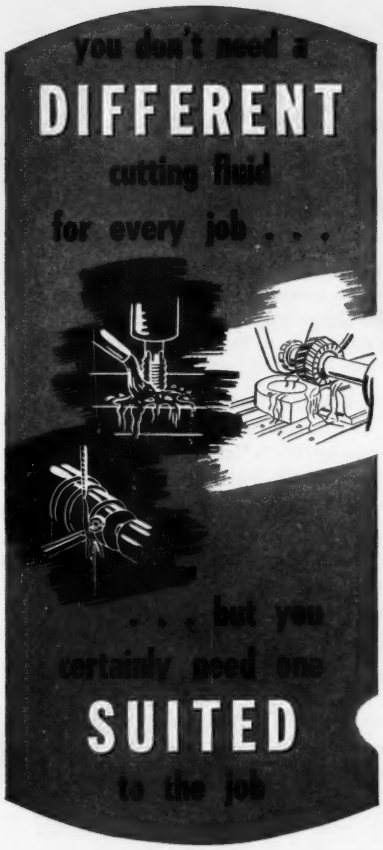
The Trabon lubricating system can be concealed on any machine . . . it can be buried in dust, dirt, water or grime . . . and withstand the heat and vibration on the toughest operation.

Trabon has the only completely enclosed measuring valve that notifies the operator if trouble develops . . . each bearing gets the right amount of clean lubricant at the right time. Longer bearing life, less down time for costly repairs, and more production are the results you get from Trabon lubrication.

TRABON ENGINEERING CORP.
1814 East 40th Street • Cleveland 3, Ohio

Trabon

OIL AND GREASE SYSTEMS



THERE is no one cutting fluid that best meets the requirements of every job. Therefore, Stuart offers you a *complete* line of cutting fluids. Often two or three Stuart cutting fluids, or varying dilutions of one or two, will answer all the needs of a shop. But, what a whale of a difference it makes when the cutting fluid that is used is the right one for the job!

GEAR SHAVING TOOL LIFE INCREASED 50%, FINISH IMPROVED WITH STUART'S THREDKUT

In a Chicago plant, two gear shavers were run side by side on the same job, one with the old cutting oil, one with Stuart's THREDKUT. Tool life with "x" oil—6000 gears; with THREDKUT —*9000 gears!* Finish with the other oil—satisfactory until 2500 to 3000 gears had been produced, then deteriorating until tools were replaced; with THREDKUT —completely satisfactory at all times.

It pays to put the *right* cutting fluid on the job. Ask to have a Stuart sales-engineer call.

● ●

Send for NEW BOOKLET entitled "MORE THAN A COOLANT IS NEEDED"

TIME-TESTED

D.A. Stuart Oil co.
EST 1865 LIMITED

2729-53 S. Troy St., Chicago 23, Ill.

Lubrication ENGINEERING

OCTOBER, 1952, Vol. 8, No. 5

TABLE OF CONTENTS

Advertisers' Index 272
Annual Meeting Hi-Lites 230
Bacterial Decomposition of Soluble-Oil Emulsions 234
by W. Sonntag
Book Reviews 255
Carbide Steel Milling With Cutting Fluids—A Progress Report 235
by J. R. Roubik
Coming Events 256
Current Literature 254
Directory, ASLE 266
Dispensing Characteristics of Lubricating Greases 247
by R. F. Strohecker
Evaluating Cuttings Oils by Determining Their Effectiveness in Reducing Sub-Surface Grain Distortion 238
by. W. E. Lauterbach and E. A. Ratzel
Fundamental Knowledge of Lubricating Grease Structure 244
by B. W. Hotten
Lube Lines 231
Lubrication in the News 253
Lubrication Summarized 251
Membership Classifications, ASLE 270
NACA Studies of Mechanism of Fretting (Fretting Corrosion) and Principles of Mitigation 241
by D. Godfrey and E. E. Bisson
New Members 256
Patent Abstracts 256
Personals 255
Steel Mill Lubrication From Management's Point of View (Practical Lubrication, No. 3) 232
by T. R. Moxley
Symposium Hi-Lites 252

LUBRICATION ENGINEERING

Published bi-monthly by the American Society of Lubrication Engineers, 343 S. Dearborn St., Chicago 4, Ill., WEbster 9-3848. $.75 single copy, $4.00 annually. Copyright 1952 by the American Society of Lubrication Engineers. Printed at Cincinnati, Ohio by S. Rosenthal & Co., Inc. The ASLE will not be responsible for statements or opinions advanced by its meetings or printed in its publications.

Editor ..... S. K. TALLEY, Shell Development Co.
Consulting Editor ..... B. H. JENNINGS, Northwestern Technological Institute
Editorial Committee ..... S. K. TALLEY, Chairman, Shell Development Co.
A. F. BREWER, The Texas Co.
E. M. GLASS, Hq. Wright Air Development Center
H. E. MAHNCKE, Westinghouse Research Laboratories
Adv. & Bus. Mgr. ..... W. P. YOUNGCLAUS, JR., ASLE National Office
Editorial Assistant ..... C. R. KLUGE, ASLE National Office

OFFICERS OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

President ..... M. E. MERCHANT, The Cincinnati Milling Machine Co.
Vice-President at Large ..... W. E. CAMPBELL, Bell Telephone Laboratories
Secretary-Treasurer ..... W. H. FOWLER JR., The Pure Oil Co.
Administrative Secretary ..... W. P. YOUNGCLAUS, JR., ASLE National Office
V-Pres., Eastern ..... H. E. MAHNCKE, Westinghouse Research Laboratories
V-Pres., Mid-Western ..... J. W. HOPKINSON, Penn-Petroleum Corp.
V-Pres., Western ..... A. S. HORWITZ E. F. Houghton & Co.
V-Pres., Canadian ..... T. A. MARSHALL, Steel Co. of Canada, Ltd.
Chairman, Pres. Council ..... C. E. SCHMITZ, Crane Packing Co.

DIRECTORS

A. E. BAKER, JR., General Electric Co.
J. BOYD, Westinghouse Electric Corp.
P. F. CHAPPELL, American Oil Co.
W. DEUTSCH, Trabon Engineering Corp.
G. FINDLAY Republic Steel Corp.
D. D. FULLER, Columbia University
N. H. SCHELL, International Harvester Co.
A. O. WILLEY, The Lubrizol Corp.

Use "Dag" Dispersions... the Really Effective Hot Metal Working Lubricants

Use **"dag"** colloidal graphite dispersions to lubricate under all conditions of extruding, deep piercing, forging, stretch forming, wire-drawing and ingot stripping... to assist in the parting of castings... to provide a lubricant that is impervious to degreasing agents... to lubricate permanently parts that may be subject to extremely high temperatures.

"Dag" dispersions protect against heat . . . fatigue failures . . . heavy loads... in short, *protect against all the causes of wear.* At virtually any temperature experienced in hot-metal work **"dag"** colloidal graphite overcomes friction and heat and keeps parts lubricated for action.

DRY FILMS of lubricant formed with **"dag"** dispersions have extremely low coefficients of friction; they resist oxidation and function far above the burning-point of conventional petroleum lubricants.

Dispersions of molybdenum disulfide are now commercially available. Experimental samples will be sent on request.

More data on the advantages of **"dag"** colloidal graphite for metal-working operations are contained in a recent bulletin available on request. Write TODAY for Bulletin No. 426-12K.

Acheson Colloids is equipped to do custom disintegrating, dispersing, and stabilizing of solids in a wide variety of vehicles. If you are in need of this type of service, tell us about it. We may be able to help you.

Acheson Colloids Company,

Port Huron, Mich.

. . . also ACHESON COLLOIDS LIMITED, LONDON, ENGLAND

Units of Acheson Industries, Inc.

dag DISPERSIONS®

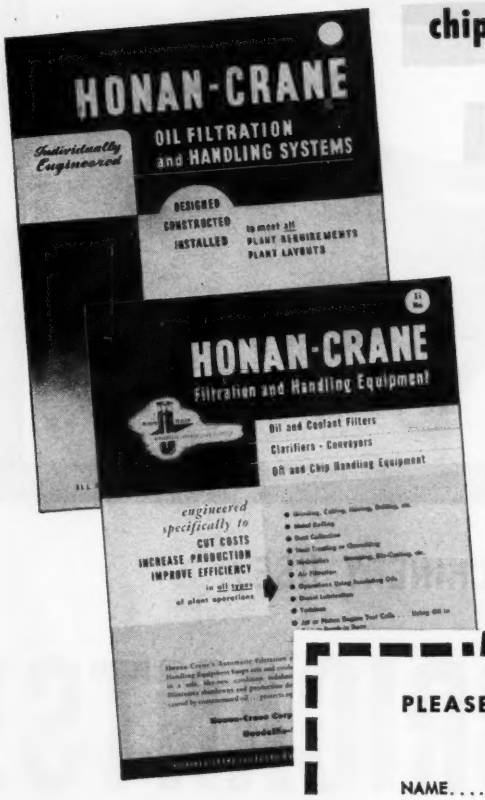
What's Your Problem?

oil or coolant filtration and handling?

filtering systems for jet or piston-engine test cells?

chip, abrasive or other waste removal?

raw materials handling?



Honan-Crane has the Right Solution

These two folders tell how dependable Honan-Crane equipment solves your filtration and handling problems and pays for itself out of savings; they give full information about Honan-Crane Engineering Service and production facilities for special installations. Get your copies NOW!

All Honan-Crane Equipment is Sold on Performance-Guaranteed Basis

Mail This Coupon for Your FREE Folders

PLEASE SEND ME FREE FOLDERS DESCRIBED ABOVE.

NAME.....

COMPANY.....

ADDRESS.....

CITY.....STATE.....

Honan-Crane Corp., 818 Wabash Ave., Lebanon, Indiana

A Subsidiary of **Houdaille-Hershey Corp.**

IN CANADA: E. W. Playford, Ltd., Montreal 28; W. E. Micklethwaite, Toronto 18; Cummings Galbraith, Ltd., Edmonton, Alta.

FOR SURE RESULTS IN RUNNING MACHINERY, USE

PENOLA LUBRICANTS!

For maximum industrial efficiency specify Penola.

Penola Lubricants are specially engineered for industrial requirements . . . high-quality products for high-quality protection.

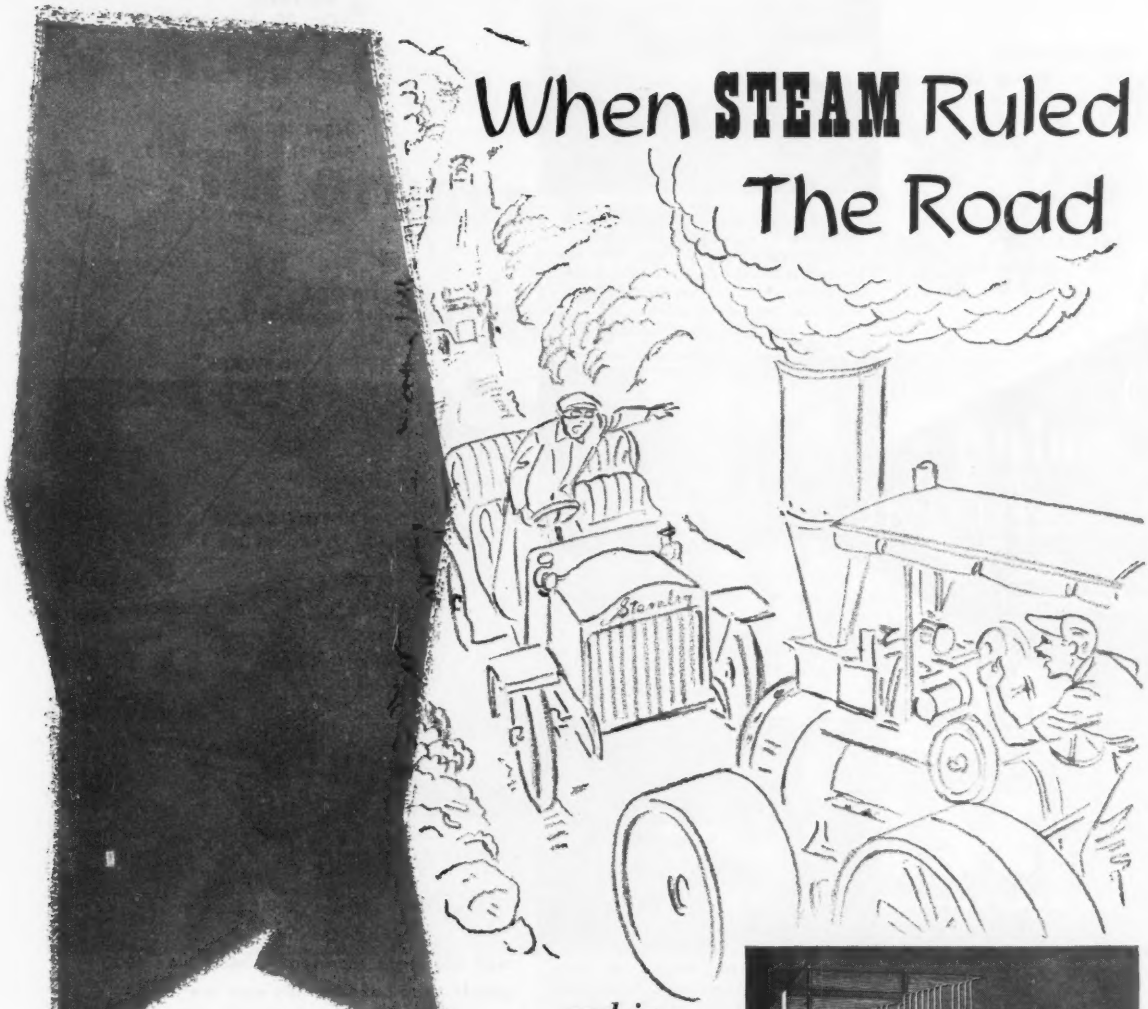
PENOLA OIL COMPANY

NEW YORK • DETROIT • CHICAGO • ST. LOUIS

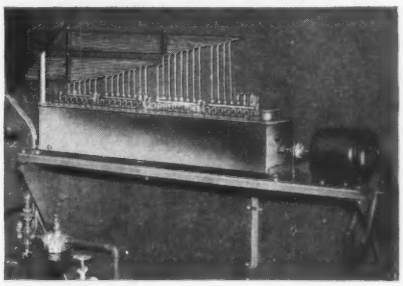
Penola

FOR EXPERT TECHNICAL ASSISTANCE — be sure to call the nearest Penola Office. Our staff of expert lubrication engineers are ready to help with *your* lubrication problems.

When STEAM Ruled The Road



... and in modern industrial plants



In the day of the Stanley Steamer, Manzel Oil Pumps were essential to dependable performance of automobiles and steam traction engines for road building, farming, and construction. Today they are even more vital in presses, engines and other industrial machinery... saving oil, reducing "down-time"— adding years of trouble-free service. Insist on Manzel-lubricated machinery. For further information write Manzel, 273 Babcock Street, Buffalo 10, N. Y.

Manzel **FORCE FEED LUBRICATION**

A DIVISION OF FRONTIER INDUSTRIES, INC.

MINNEAPOLIS
Sept. 29, through Oct. 1.

MILWAUKEE
Oct. 7, through Oct. 10.

ST. LOUIS
Sept. 23, through Sept. 26.

BUFFALO
Oct. 29, through Oct. 31.

NEW HAVEN
Nov. 11, through Nov. 13.

BALTIMORE
Nov. 18, through Nov. 20.

NEWARK
Nov. 4, through Nov. 7.

CINCINNATI
Oct. 21, through Oct. 23.

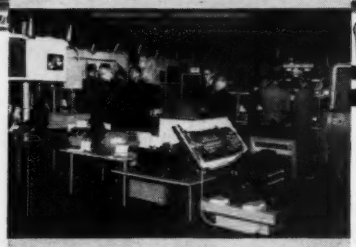
WINSTON-SALEM
Dec. 9, through Dec. 11.

Coming to help you

solve problems in design and production!

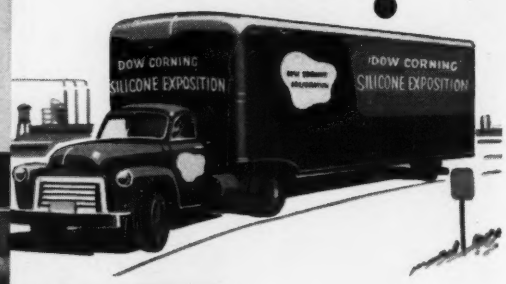
"BRINGING the mountain to Mohamet might best describe Dow Corning Corp.'s traveling exhibit . . . Free standing panels . . . separate the exhibit into nine bays, each emphasizing a property of silicones and showing where that property brings a benefit to an actual end product or operating unit . . ."
INDUSTRIAL MARKETING (June 1952)

"NEXT TO THE GREATEST SHOW ON EARTH . . . We could go on . . . reciting the fantastic properties of Silicones, but just as breathtaking as the materials were the display techniques used to demonstrate them . . ."
CIRCUIT RIDER (Vol. 6, No. 2, published by Electrical Construction and Maintenance)



". . . Heat Stability Plus: Visitors . . . see, among other demonstrations, how Silastic (Dow Corning's silicone rubber) remains soft and flexible at temperatures far above the limits of organic rubber . . ."
CHEMICAL WEEK (Jan. 26, 1952)

"IF YOU HAVEN'T already seen it, don't miss it when it comes around . . ."
POWER ENGINEERING (May 1952)



DOW CORNING SILICONES . . . are no longer a mystery or a "future possibility" to the 17,000 executives and engineers, representing more than 4600 plants, who have already seen the Dow Corning Silicone Exposition.*

They learned that silicones are fluids and resins that keep clothes and shoes and brick walls dry in the rain. They're fluids that polish without rubbing.

They're rubber that won't melt on hot aircraft engine cylinders or freeze on switches that operate bomb bay doors at 100° below zero.

They're electrical insulating resins and varnishes that double the power of electric motors, or multiply by 10 the life of electric machines.

They're paints that protect metal at 1000°F. They're foam killers and release agents. They're a whole family of new engineering materials that can help you to improve your product or to cut production costs.

*In Boston • Chicago • Cleveland • Dayton Detroit • Fort Worth • Houston Indianapolis • Los Angeles • New York Philadelphia • Pittsburgh • Seattle Washington, D.C. • or Wichita.

DON'T MISS IT

MAIL THIS COUPON TODAY

Dow Corning Corporation, Dept. BW-22
Midland, Michigan

Kindly include me among your guests at the private showing of the Dow Corning Silicone Exposition in

☐ St. Louis ☐ Buffalo
☐ Minneapolis ☐ Newark
☐ Milwaukee ☐ New Haven
☐ Cincinnati ☐ Baltimore
☐ Winston-Salem

NAME _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____

Atlanta
Chicago
Cleveland
Dallas
Los Angeles
New York
Washington D. C.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

CANADA: Fiberglas Canada Ltd., 1200 Bay St., Toronto, Ontario
ENGLAND: Midland Silicones Ltd., 49 Park Lane, London, W.1

Now—One grease will service all grease applications in the majority of plants

Gives ALL THESE PLANT SAVINGS:

1. **Extends TIME between greasings**—lasts longer . . . stays in bearings longer.
2. **Low-cost application**—fewer servicings and *only the one grease* to handle.
3. **Simple inventory**—Shell Alvania Grease replaces up to 20 brands formerly required.
4. **Better protection**—against heat, cold and moisture.
5. **Greater safety**—less chance of applying the wrong grease!

Gives ALL THESE LUBRICATION ADVANTAGES:

1. **Higher mechanical stability** than any conventional grease at operating temperatures.
2. **Pumpable at low temperatures**—even in unheated storage.
3. **Stable at high temperatures**—superior to the best "soda" greases.
4. **Impervious to water**—excellent resistance to washing out.
5. **Longer service life**—reduced consumption.

The "MILLION-STROKE" Industrial Grease!

A grease that will stand 100,000 punishing strokes of the ASTM Work Tester has been considered a superior lubricant.

In a deliberate attempt to break down Shell Alvania Grease, *on the same tester* the run was extended...200,000 strokes...300,000 strokes . . . 500,000 strokes! Finally, at one million strokes the test was discontinued, because this grease *would not break down*—it was still a fit lubricant both in appearance and consistency.

SHELL OIL COMPANY

50 West 50 Street, New York 20, N. Y. • 100 Bush Street, San Francisco 6, California

SHELL®

SHELL ALVANIA . . . The "MILLION STROKE" Grease

"Tycol Acylkup boosts bearing life... smooths the way for heavier loads"

Of course! Tycol Acylkup Bearing Grease "stays put" . . . keeps anti-friction bearings running smooth and cool. Finest quality neutral oils give it high load-carrying capacities. Tycol Acylkup is firmly resistant to the washing action of water. Its dependable lubricating abilities lengthen bearing life and reduce maintenance costs. Call your nearest Tide Water Associated office for further information.

TYCOL

INDUSTRIAL LUBRICANTS

Boston • Charlotte, N. C. • Pittsburgh
Philadelphia • Chicago • Detroit
Tulsa • Cleveland • San Francisco

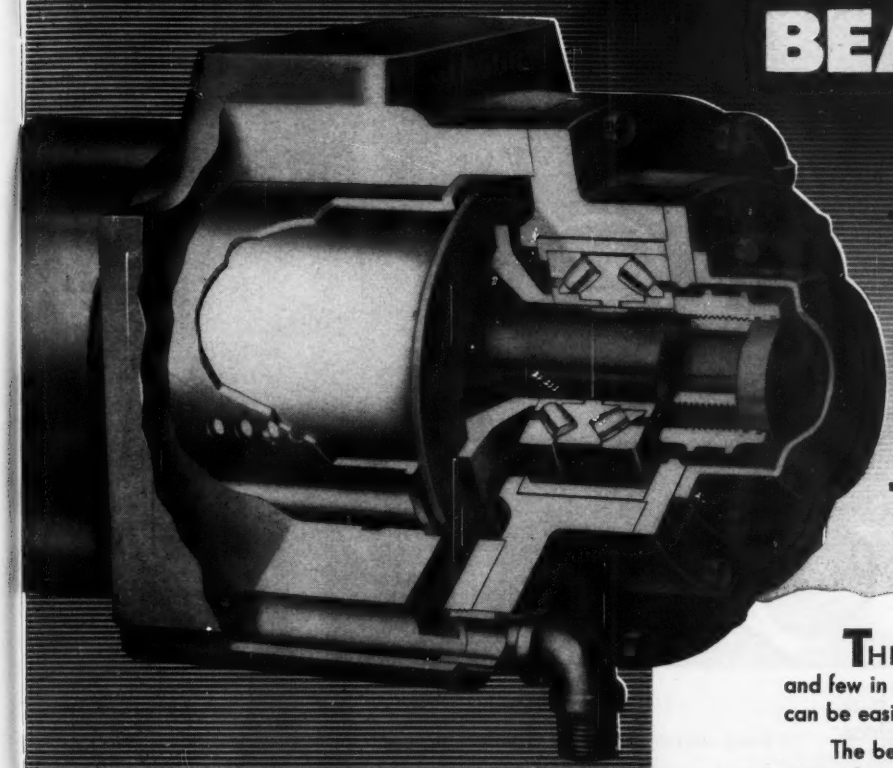
TIDE WATER ASSOCIATED OIL COMPANY

17 BATTERY PLACE · NEW YORK 4, N.Y.

SEND FOR A FREE COPY OF "TIDE WATER ASSOCIATED LUBRICANIA"

MORGOIL

ROLL NECK BEARINGS



....insure accurate products

...last a long time

....require little maintenance

MORGAN
WORCESTER

ROLLING MILLS · MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - AIR EJECTORS
REGENERATIVE FURNACE CONTROL

THE essential parts of the bearing are simple and few in number . . . making a compact unit that can be easily removed from the roll neck.

The bearing operates on a film of oil which has tremendous load carrying capacity, hence there is no wear. The load is distributed over a large area with no points of concentration, so fatigue failures of bearing parts are unknown.

The operation of a bearing under hydro-dynamic lubrication results in an extremely low coefficient of friction and low power requirements.

The absence of wear in the radial bearing and the close control of axial roll movement afforded by the thrust bearing, permits the rolling of both sheets and sectional products within extremely close tolerances.

May we tell you more about the success of Morgoils on new or existing mills?

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

English Representative: International Construction Co.
56 Kingsway, London W C. 2, England

MB-16

You can't SEE these extra qualities in HOUGHTON'S HYDRO-DRIVE...

... but you can prove they're there by using this scientifically fortified hydraulic oil!

HYDRO-DRIVE STARTS OFF as a high quality base petroleum oil, but Houghton "know-how" steps in to provide:

HIGH FILM STRENGTH—the result of a chemical additive which Houghton engineers discovered gives hydraulic equipment extra long protection against wear.

OXIDATION STABILITY—special treatment that lengthens oil life and makes hydraulic machines perform more smoothly.

GUM SOLVENCY—an added property to keep damaging gums from collecting inside the machines.

RUST INHIBITOR—to safeguard precision equipment against costly rust damage.

Your high precision hydraulic operations call for more than just straight run oils . . . they'll perform better and last longer on Hydro-Drive fortified oil.

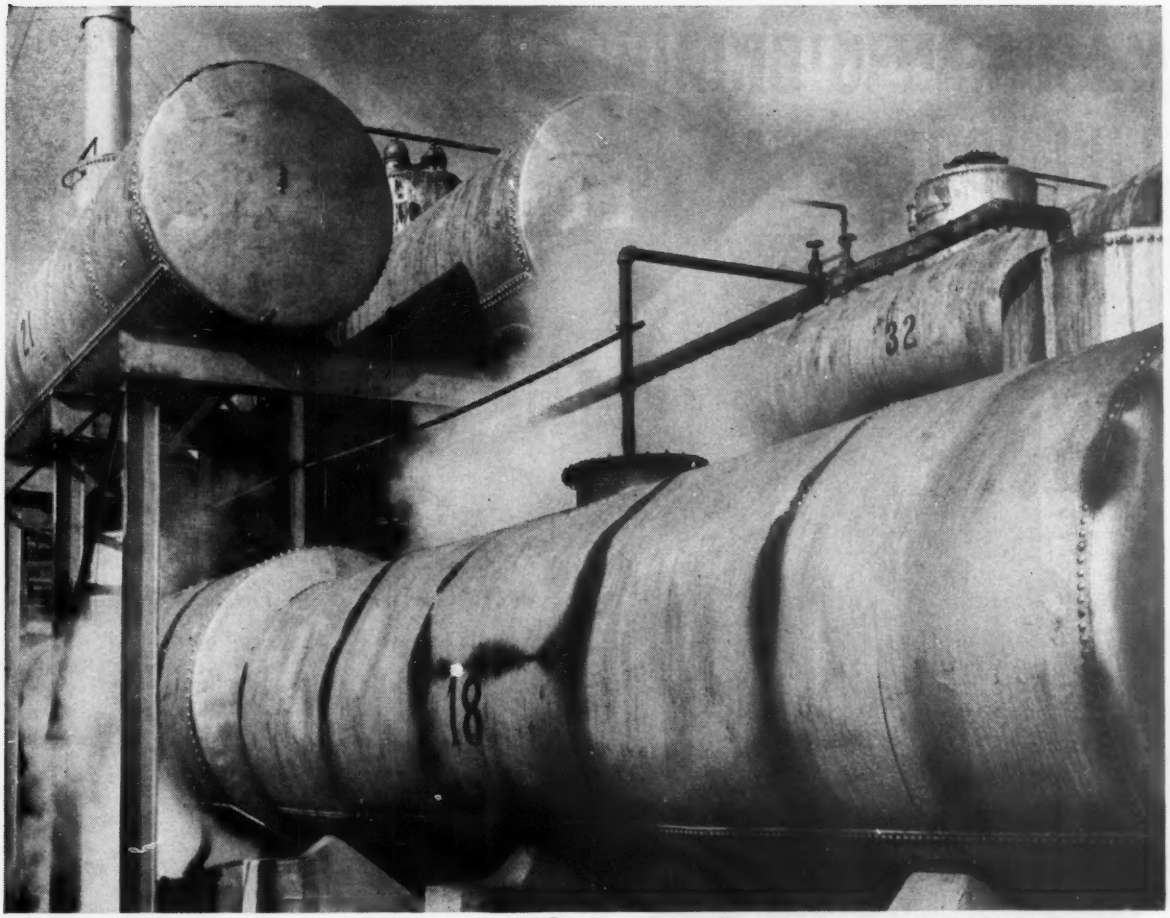
GET FULL INFORMATION by asking the Houghton Man for latest Hydro-Drive Bulletin and prices. Or write to E. F. Houghton & Co., Philadelphia 33, Pa.

HYDRO-DRIVE . . . *a product of*

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service...



Buy it as you use it . . . get it when you want it. In this huge battery of heated tanks newly made Palmoshield is stored, ready for immediate shipment.

Not half a world away

. . . right in the heart of the industry!

Threats of war . . . shipping uncertainties . . . materials shortages. These headaches fade away when you use Palmoshield as the essential lubricant in your rolling operations.

For Palmoshield is an all-American lubricant made from freely available domestic materials in centrally located Columbus. You buy it as you use it. You get it when you want it. You need not tie up space or funds in stockpiling.

Introduced in January, Palmoshield is already in general use or on test by two-thirds of the major tin-plate producers of this country and Canada. Months of on-the-job experience have established the new lubricant as a proven replacement for imported palm oil.

Palmoshield is subject to exact chemical control; you can specify free fatty acid content to ½%—and get it. It looks, feels, acts, handles like palm oil; requires absolutely no changes in mill operation. It improves production, gives increased tonnage at less cost. Its price is not artificially controlled, but rises and falls freely with the domestic fat market.

To meet expanding demand, manufacturing and storage facilities have recently been greatly enlarged. Palmoshield is now available for immediate shipment in any quantity in both 55-gallon drums and tank car lots. For details write The Ironsides Company, 270 West Mound Street, Columbus, Ohio.

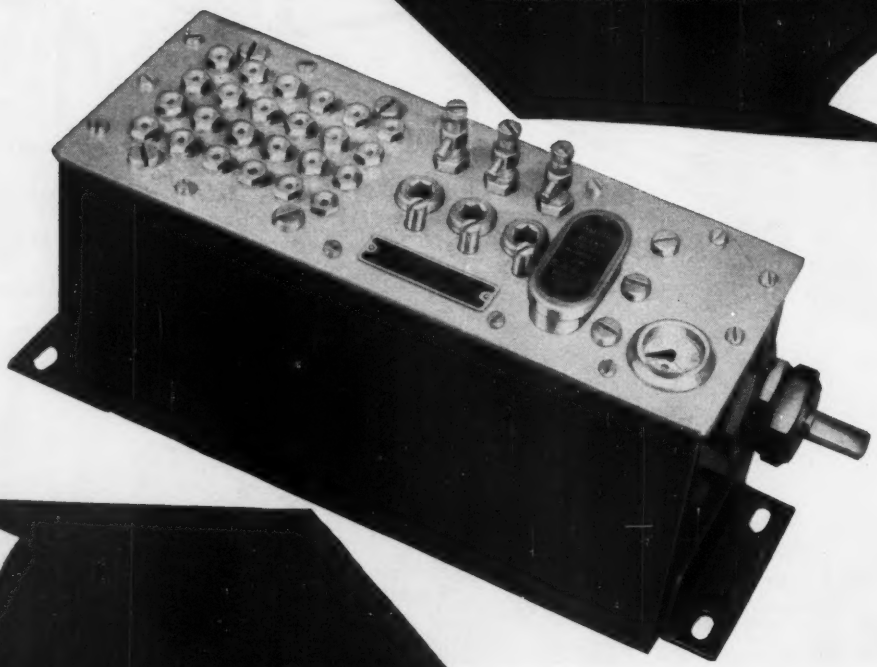
In emergencies overnight shipment can be made direct to your mill by tank truck not dependent on rail schedules.

SPECIAL LUBRICANTS and PRESERVATIVES

IRONSIDES SHIELD PRODUCTS **PALMOSHIELD**

MADISON-KIPP

Fresh Oil LUBRICATORS



THE MOST DEPENDABLE OILING SYSTEM EVER DEVELOPED!

MEASURED FEED DROP BY DROP FED UNDER PRESSURE!

MACHINE performance is in direct relation to the quality of the oiling system! And that's why builders of America's finest machine tools, work engines and compressors specify Madison-Kipp "Fresh Oil" Lubricators as original standard equipment . . . because they provide the most dependable oiling system ever developed . . . measured feed, drop by drop, fed under pressure. There are six models to meet almost every application requirement. Illustrated is the Model FD. Please address all inquiries to the home office in Madison, Wisconsin

MADISON-KIPP CORPORATION

223 WAUBESA STREET, MADISON 10, WIS., U.S.A.

ANCIENS ATELIERS GASQUY, 31 Rue du Marais, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS

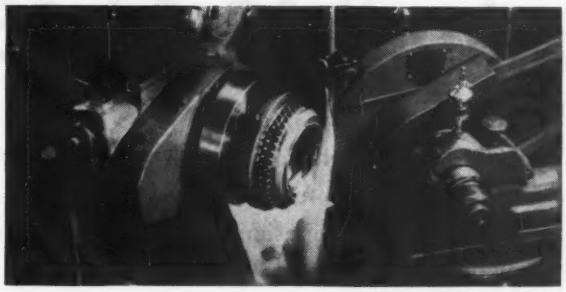
S.E.C.O. SPEEDS MACHINING OPERATIONS, REDUCES REJECTS, INCREASES TOOL LIFE

For any machining operation where an oil of its type can be used, Sunoco Emulsifying Cutting Oil will boost production, reduce downtime for cleaning and tool dressing.

A self-emulsifying petroleum product, S.E.C.O. forms a stable white emulsion when mixed with water. Its cooling and lubricating qualities make it particularly effective in the high-speed precision machining of ferrous and nonferrous metals. S.E.C.O. keeps machines clean, has a pleasant odor, and prevents rusting of parts between operations.

For complete information about S.E.C.O., write SUN OIL COMPANY, Philadelphia 3, Pa. Address Department LE-10.

MACHINE: 2" automatic tapping machine • Parts: pipe fittings Metal: malleable iron • Operation: threading and chamfering 1½" 45° elbow • Cutting Speed: 75 sfm • Tools: high speed • Production: 306 pieces per hour • Cycle Time: 11¾ seconds • Cutting Oil: 1 part S.E.C.O. to 10 parts water



COURTESY BROWN & SHARPE MFG. CO.

MACHINE: Brown & Sharpe No. 2 Universal Grinding Machine Part: screw machine spindle sprocket • Metal: AISI-C1107 • Operation: grinding 90° included angle • Method: plunge-cut ground periphery of wheel • Grinding Oil: 1 part S.E.C.O. to 40 parts water

MACHINE: Gisholt turret lathe, model 4L • Part: 20" press mold shell, 22⅝" O.D., 6" depth, 20½" I.D. • Operation: turning and boring rough forgings • Materials: 40 to 50 carbon steel • Tools: Firthite carbide • Feed: .012 at 31 rpm • Cut: ½" to ¾" on O.D. and boring • Cutting Oil: 1 part S.E.C.O. to 10 parts water

SUN INDUSTRIAL PRODUCTS

SUN OIL COMPANY, PHILADELPHIA 3, PA. • SUN OIL COMPANY, LTD., TORONTO AND MONTREAL

SUNOCO®

PLAN NOW to attend the

1953 ASLE

Annual Meeting

April 13-14-15

Hotel Statler Boston

PROGRAM PLANS for the 8th Annual Meeting and Exhibit of the American Society of Lubrication Engineers to be held on April 13, 14, and 15, 1953, at the Hotel Statler, Boston, include three symposiums, a round table forum, and thirty-four technical papers. A portion of this program includes the following:

Symposia: DIAGNOSING BALL AND ROLLER BEARING TROUBLES BY VISUAL INSPECTION
DIAGNOSING SLEEVE BEARING TROUBLES BY VISUAL INSPECTION

Forum: ASPECTS OF HYDRAULIC MACHINERY AND EQUIPMENT (with audience participation)

Papers: DESIGN AND SERVICE REQUIREMENTS DICTATE THE CHARACTERS OF OIL ADDITIVES, by E. C. Knowles & G. R. Furman, The Texas Co.

PROPERTIES OF LUBRICANTS THAT ARE DESIRABLE FOR USE WITH VARIOUS TYPES OF BEARING METALS

VISCOSITY STUDIES OF FLUID LUBRICATION AT HIGH PRESSURES, by Dr. L. B. Sargent, Jr., Aluminum Research Laboratory

AIR BEARING STUDIES AT NORMAL AND ELEVATED TEMPERATURES, by J. D. Pigott & E. F. Macks, N.A.C.A.

DEVELOPMENT OF SIGNIFICANT BENCH TESTS FOR AIRCRAFT TURBINE OILS, by A. E. Ryder, Pratt & Whitney

LUBRICATION IN THE DESIGN AND OPERATION OF TEXTILE MACHINERY, by R. M. Jones, Saco-Lowell Shops

Lube Lines

THE NEW LUBRICATION ENGINEERING

In this, the second issue of the new LUBRICATION ENGINEERING, every effort is being made to continue improving the appearance and the content of the Society's Journal. The close co-operation of the Editorial Committee has provided a schedule of more papers per issue, almost double the number that have appeared in previous issues, and the use of Futura type-face has permitted their publication. Address any comments to The Editor, LUBRICATION ENGINEERING, 343 S. Dearborn St., Chicago 4, Illinois.

40th ANNUAL NATIONAL SAFETY CONGRESS

The First Co-operative Safety Congress, held in 1912 under the auspices of the Association of Iron and Steel Electrical Engineers, directed the president of the association to appoint a committee authorized to organize and to create a permanent body devoted to the promotion of safety to human life in the industries of the United States. This committee offered itself as the nucleus of such a body and, with the addition of representatives from other organizations, became The National Council for Industrial Safety. In the following year its name was changed to the National Safety Council. 1952 marks the 40th annual convention of the National Safety Council, to be held in Chicago October 20-24 and dedicated to celebrating and commemorating four decades of safety with emphasis placed on the co-operative nature of the safety movement in which scores of safety organizations pool their efforts and resources in a combined fight against accidents. More than 600 speakers will appear at 200 sessions, covering every conceivable phase of safety; in addition, the Congress exposition will contain about 250 exhibits covering all types of safety aids.

THE CARE AND FEEDING OF LUBRICANTS*

Oils and greases not only must be correctly handled, they must also be properly stored, if they are to be maintained in the condition in which they are shipped by the oil refiner. Refiners go to considerable trouble and expense to make certain that lubricants are packed in moisture- and dirt-free containers. The containers also are well sealed to prevent the entrance of water and dirt. Tanks on tank trucks and railroad tank cars are cleaned thoroughly on the inside before any lubricant is allowed to enter. Filling spouts and all other parts of tank-filling apparatus which can be touched by lubricants are cleaned before any pumping is done. The men at bulk plants are trained to keep all tanks, filling spouts, drums, barrels and other containers as clean as possible. They check and double check to be sure that cleanliness is maintained of all parts likely to be touched by oil. Men in industrial plants should do likewise.

The men assigned to store, handle and dispense lubricants should be well trained. There is no more important procedure than delivering the right lubricant to the right place at the right time. The lubricant should be free from dirt and moisture or other contaminants when it is delivered to a machine. Oil or grease which falls or drips to the floor should be removed as quickly as possible. Such areas not only present fire hazards but they may cause persons to be injured in case the oil makes them slip or fall.

Lubricating oils are shipped in tanks on trucks and railroad cars and in barrels or smaller containers. Greases are usually shipped in 400- and 100-pound drums and in 35-pound pails with removable tops. Fluid-type greases are generally shipped in barrels, and block greases, which are relatively hard, are shipped in boxes or cartons.

When tank trucks or tank cars arrive at a plant and are ready to be emptied of oil, men in charge of transferring the oil to storage tanks should make certain that receiving lines are clean. If the line has been plugged with cotton waste or rags, as is customary to prevent the entrance of dirt, the plug should, of course, be removed. If removal of the plug is forgotten, much trouble may result. In the case of cotton waste, the strands may eventually plug an oil line in a machine. The rag may cause stoppage of oil flow from the storage tank. It is better to tie cloth over the outside than to stuff waste or rags into the end of a line.

Storage tanks mounted outdoors are usually fitted with steam coils around the suction line. During cold weather, particularly, if the steam line is not opened after a viscous oil is poured into the tank, it may require many hours to heat the oil so it will flow freely from the tank. Outdoor and indoor tanks generally feed oil by gravity to indoor storage or directly to machines which use the lubricants.

In some plants, such as large utilities which employ a number of steam turbines, oil storage tanks may be located on the top floor or roof of the turbine building. The oil from these tanks is fed by gravity directly to turbine oil reservoirs. There are flow-meters and controls on each reservoir line.

Whether storage tanks are indoors or outdoors, the man in charge of them should be sure that they are fitted with draw-off cocks so that any water which has collected in the bottom of the tanks as a result of moisture condensation may be drained off periodically.

When barrels of oil are received at a plant and left outdoors for any length of time, the barrels should not be temporarily stored on end but always on their sides. This keeps the bungs oil-wet on the inside and prevents the barrels from "breathing" in air. Air contains moisture which would enter in vapor form and condense into droplets of water as a result of temperature drop. Water is an oil contaminant. Air breathing is more pronounced when the temperature is high during the day and much lower at night. But even during winter months breathing might take place, particularly if the barrels are allowed to stand in the sun.

When an oil barrel is empty the bung should be replaced and the barrel returned. If it is kept on the factory premises it may be used again and with bad results. This happened at a plant which stored oil barrels under an outdoor shed. When the barrels became empty or nearly so, the workers used them as oil storage tanks. New barrels which arrived at the plant were emptied into the old barrels which gradually accumulated dirt and water. In some cases different oils were mixed because care was not taken to see that the same kind of oil was always dumped into the old barrels. The result here was that the plant was using dirty, mixed oil. The condition was corrected only after damage to machinery occurred and the cause tracked down.

If barrels of oil are stored indoors they should be taken to the oil house or other storage area as quickly as possible after arrival at a plant. Where few barrels are handled they should be laid on their sides on a rack, platform or cradle so that the faucet is at a convenient point for use. The faucet and the area around the bung should be kept clean at all times by wiping the areas with clean rags. If barrel-type pumps are used, there should be a separate pump for each barrel. When the barrel is empty, the pump should be installed on another barrel containing the same product. Pumps should never be allowed to rest on a floor or other place where they can pick up dirt. This precaution should be followed with all devices, parts and equipment which may be coated with oil or grease. *(Continued on page 258)*

* Reprinted in part from ESSO OILWAYS

STEEL MILL LUBRICATION FROM MANAGEMENT'S POINT OF VIEW*

by T. R. Moxley
Wheeling Steel Corp.
Steubenville Works
Steubenville, Ohio

Mr. Moxley served his machinist apprenticeship in the Shops and Engineering Dept. of the Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., advancing to the capacities of Machine Shop Foreman and Ass't. Master Mechanic of the Sheet Mill. After three years as Master Mechanic of By-Products with the Woodward Iron Co., he became associated with the Wheeling Steel Corp., Steubenville Works, as Master Mechanic of the By-Product Coke Plant, later as Mechanical Superintendent of the Steubenville Works. In 1950 he was promoted to Ass't. General Manager.

The subject of steel mill lubrication from the viewpoint of management is an undertaking of considerable magnitude. Investigation of the several aspects of the subject involves not only lubricants and their application but also the performance of modern machinery, personnel training and application, engineering, and many other variables.

During the past quarter of a century, we have seen the greatest and most rapid improvement in the design and application of steel mill equipment that has ever been experienced since the days of Andrew Carnegie. Gone are the days of the old hand mills, puddle furnaces and hand-filled Blast Furnaces. Likewise, the two-gallon bucket with the associated paint brush, the long-spout oil-can, the standard red engine-oil, old type cylinder oil; and No. 1 and No. 2 cup grease have gone with the wind. All of these are fond memories to those of us who have grown with the business during these many years. Yet, I sometimes wonder if we, who are entrusted with the science of lubrication, have grown proportionately with the growth of the equipment we are expected to protect through the medium of lubrication.

We, as lubrication engineers, recognize the co-operation and assistance afforded us by our friends in the petroleum industry. They were alert to the radical development in design of steel mill machinery and immediately began a research program for the development of lubricants that would meet the requirements of our industry. During the early stages of this new development, the men of the petroleum industry were our constant companions from whom we received our initial training. They have since provided libraries of information for our guidance and assistance in the discharge of our respective responsibilities.

The same is true of those manufacturers who formerly supplied us with grease cups, oil cups, lubricators, oil cans and the like, and who are now engaged in the manufacture of modern, automatic appliances for the efficient application of steel mill lubricants.

Presented with the facts that we now have at our disposal, namely the proper lubricants and appliances for their application, it is our duty to apply ourselves diligently to the attainment of a thorough knowledge of the science of lubrication that will better enable us to discharge the responsibilities of our profession.

Applied lubrication is essentially allied and interwoven with operation and maintenance to the extent that to consider one without the other would be a grave mistake. There must be a thorough working arrangement and co-operative understanding in this connection between the operation, maintenance, and lubricating personnel.

In order to attain the desirable objective, the selection of directive supervision is a factor of major importance to steel mill management. Authority and responsibility, of necessity, should be invested in a direction conducive to the elimination of unnecessary red tape, so to speak. Divided authority and responsibility will only result in confusion and misunderstanding.

The extent to which a structure of authority is to be organized will depend largely upon the required services involved. Usually those services which are applicable to steel mills justify a self-contained lubrication department in which the combined authority and responsibility of engineering, application, and maintenance is thus supervised and directed.

Naturally, in this connection, co-operative procedure throughout the entire operative and maintenance personnel is extremely essential. Experience has proved that, without such co-operation, an investment in the most modern lubricating equipment and lubricants will profit nothing and such a course may even prove disastrous through the failure of expensive equipment and loss of production. It is recognized that the lubrication engineer and his immediate associates, in addition to their ability as engineers, of necessity must also be adept in the application of psychology and salesmanship, to educate those less-informed in this business of modern lubrication.

The present trend of overall expansion for increased steel production, as previously referred to, presents to management the never ending problem of modernization, either of existing facilities or replacement with facilities of modern design. Usually this program must be planned and scheduled in a manner that will not interfere with regular operations or, with the least possible interruption to production. This requires engineering, not only of the physical construction of equipment, but also methods of procedure in detail down to the installation of the last bolt and the assignment of each man-hour of effort.

During the process of this engineering and planning, it is essential that lubrication be carefully analyzed in detail

* Sponsored by the Technical Committee on Lubrication Equipment and presented at the 7th Annual Meeting, ASLE, Cleveland, April 7, 1952.

to assure the proper admission of the lubricant, and protection of bearings, gear drives, and the like against the infiltration of mill scale, water and other foreign matter. If automatic grease systems and oil circulating systems are involved, which usually is the case, careful consideration must be given in the selection of these systems as to their efficiency, simplicity of design, ruggedness and, in the event of difficulty, accessibility of all parts for ease of cleaning or repair. The adoption of a standard design is also advisable wherever possible. While other items are of importance in the matter of detail, the above mentioned will result in minimum maintenance cost, assure lubrication, and simplify the training of operating and maintenance personnel.

The achievement of the ultimate in lubrication is the dream and ambition of those who have cast their lot in this direction. This can be accomplished by the harmonious co-operation of the lubrication and design engineer in effecting proper design and application, and subsequently applying the same method during the process of installation, and, finally. untiring effort in the training of operating and maintenance personnel.

Proper devotion to these principles will assure management of the contemplated production results anticipated when approving appropriations for such expansion programs.

The subject of lubrication and related subjects is applicable to any business and particularly the manufacture of steel wherein is employed manpower ranging from the common laborer to the highly skilled craftsman, and also includes the practical engineer and the industrial relations expert. The development of personnel, especially management personnel, is a matter of vital concern. As time is no respecter of human life, those of us who have directed the affairs of our respective positions and collectively achieved the ambitions of our objective so that today the steel industry is recognized as the barometer and standard of efficiency in American business, will some day pass on with the hope of enjoying the happy reflections of a well-spent life.

In this connection, the monument that will testify to our success are those people whom we have trained to succeed us. The need for talent brought about by the tremendous expansion of steel manufacturing facilities is more prevalent today than ever before in the history of steel.

In addition to the practical functions applicable to the mechanics of our profession, whether it be lubrication or any other phase of the business, we have an added responsibility, that of training personnel, not only in the economics of practical application of facilities, but also of human relations, especially those persons selected as potential supervisors.

To me, the most challenging problem in any business, and especially ours, is the development of management people. The management of a business has no inherent rights other than those it continues to earn for itself year by year through demonstrating its ability to manufacture a saleable product at a reasonable profit, beneficial to all concerned. It must select, train, and develop management people, to cope with the social and technical problems of our everyday life. To succeed in building an organization not only for the practical application of facilities of materials and equipment but more especially supervision personnel, the development of future management people must have high priority on the time and the planning of those entrusted with the responsibility of company policy. The development of the individual requires time and patience. It is necessary to know the individual and to feel it our duty to help build for him a success comparable with the potentials of his talents. In choosing a career, there must be a beginning, whether it be planned or accidental, thus it devolves upon management the responsibility of selecting the individual. This is the most important step of the beginning. In the process of selecting people of the right material, we must formulate a specification of what management needs in people who are expected to progress in the management family. This is essential in order to avoid improper selection, and the loss of valuable time

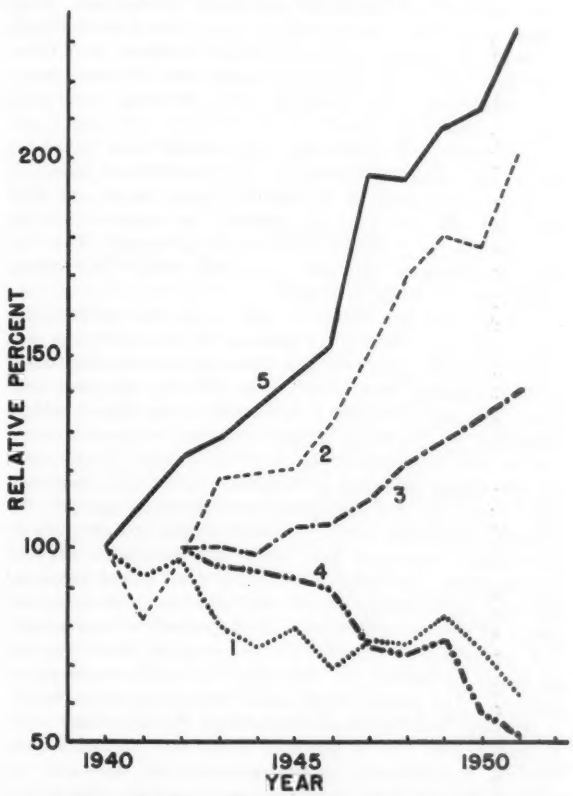


Fig. 1 Comparative lubrication and maintenance costs for a plant of the Wheeling Steel Corp. from 1940 to 1951. Key: 1—Average Lubrication Cost Per Ton; 2—Average Maintenance Cost Per Net Ton; 3—Average Lubricant Cost Per Pound; 4—Lbs. Lubricants Consumed Per Ton of Steel Rolled; 5—Average Hourly Rate Increase.

to both parties. Assuming the educational background of the individual to be satisfactory, other qualifications of equal importance must be considered, including such items as character, courage, common sense, ability to think and reason, initiative, resourcefulness, a belief and confidence in the future, and especially not afraid to extend his efforts beyond that required of his immediate responsibilities. In

(Continued on page 258)

PLANNED LUBRICATION AS A PART OF PLANT MAINTENANCE, by T. R. Witt, Tennessee Eastman Co., Division of Eastman Kodak Co., will be featured in the December issue of LUBRICATION ENGINEERING as the fourth in the series of Practical Lubrication articles. At the conclusion of this series, the Society will publish the papers in book form as another of its practical lubrication manuals.

BACTERIAL DECOMPOSITION OF SOLUBLE-OIL EMULSIONS*

by W. Sonntag
Mollenberg & Sonntag
Cranachplatz 1
Dusseldorf, Germany

The stability of soluble-oil emulsions in hydraulic press systems and their maintenance in good operation is always a matter of concern to the lubrication engineer. It is therefore worthwhile to record our experience with one case in the expectation that it will be useful to others confronted with a similar problem.

Recurrent difficulties were experienced over a period of a year with oil separation and black scum formation in the accumulator of a hydraulic press system, of 6350 U.S. gal. (24 cubic meters) capacity, whenever circulation was halted for a period of 24 hours or longer. The fluid was a soluble-oil emulsion, containing about 2%v added soluble-oil to inhibit corrosion.

Initially the failure was thought to be due to the breaking of the emulsion by the hardness of the water and was investigated by substituting a lime-stable emulsifying agent in the original formulation. The difficulty persisted and, since the scum emitted a foul odor of hydrogen sulfide, indicative of bacterial action, attention was next turned to the use of a germicide. Each addition of a germicide to the system afforded a temporary relief and confirmed this hypothesis. For reference, the emulsifying agent in the original soluble-oil was a mixture of the sodium salts of sulfonated, long-chain fatty acids and sulfonated alicyclic hydrocarbons (petroleum sulfonates) plus glycol esters of alicyclic monocarboxylic acids and stabilized with potassium soaps of diterpene carboxylic acid (potassium rosin soaps). The emulsifiers in the lime-stable emulsions were mixtures of highly sulfonated fat and ethylene oxide condensation products. The nature of the bactericides is given in Ref. 1.

Having thus tentatively established that the black scum formation was due to bacterial action, the various waters entering the hydraulic system, purposely or otherwise, as well as the emulsion itself, were analyzed in order to explore this aspect of the problem. The results are tabulated in Table I. The tap water, Column A, used as the supply for the system, is good water with low hardness. The emulsion, Column B, shows a decided increase in hardness, which must be due to contamination. Further, although this emulsion was made with the lime-stable emulsifier, it contains only 0.2% oil or roughly only 1/10 of that originally added when it was freshly made two weeks earlier.

The scum from the accumulator, obtained after an idle period, contained about 10% oil and nearly 1% black iron sulfide. Treatment of the black iron sulfide with HCl showed the iron to be in the bivalent, ferrous form.

The analysis of the ground water is shown in Column C. It originates from two sources, the Ruhr, which is clean and the Emscher, which is contaminated by industrial wastes. It is distinctly harder than the tap water but is still of fair quality. The surface drainage water, Column D, obtained from seepages from the concrete wall of the cistern, is very high in hardness and also shows an exorbitantly high content of ferric hydroxide. It is believed that the high iron content is a contributing factor in the development of the black scum as is outlined below.

It is the opinion of an expert, who was consulted on this problem, that the bacteria, which brought about the decomposition of the emulsions, were SPORO-VIBRIO DESULFURICANS. These bacteria develop vigorously in the circulation system and, in the absence of oxygen, as when the system is idle and air is not entrained, they attach such sulfur compounds as the sulfates and sulfonates and chemically reduce them to yield hydrogen sulfide. The latter may be released as such, giving rise to a vile smell, or may react with iron hydroxide to yield black iron sulfide. The destruction of the sulfonates, the emulsifying agent, breaks the emulsion and releases the mineral oil which combines with the finely divided black iron sulfide to yield the above-mentioned black scum. The iron hydroxide also undoubtedly assists in the breaking of the emulsion and the release of oil.

TABLE 1
ANALYSIS OF WATERS AND EMULSION

	A Tap Water	B First Emulsion after 14 days	C Ground Water	D Surface Drainage Water
Carbonate hardness, as $CaCO_3$, ppm	61	299	155	
Total hardness, as $CaCO_3$, ppm	80		368	
Permanent hardness, as $CaCO_3$, ppm	20		214	
pH	6.5	7.0	7.0	6.7
Dry residue, ppm	223	3564	949	22000
Ash, ppm	174	560	699	16000
Kind of ash		iron oxide, Na, Ca		ctg. 1.21% Fe_2O_3
Phenolphthalein alkalinity	0	0	0	0
Methyl orange alkalinity	1.2	6.0	3.1	5.0
Oil released by HCl, %v		ca 0.2		

As means of offsetting the phenomena described, the following are recommended: 1. Maximum cleanliness of the entire circulation and absolute compactness of the accumulator against penetration must be initially effected in order—as shown in this illustration—to make the influx of iron-bearing surface water impossible. 2. Increase in pH from 7 to approximately 8.2, i.e., development of a stronger alkaline reaction in the press water, in order thus to limit the life possibility of the sulfur bacteria, for sulfur bacteria require waters of pH 7 or lower for their development. This point is most important. 3. Furthermore, since the bacteria can thrive best in a so-called "reduction system," thorough aeration of the entire circulating system is absolutely necessary, e. g., by directing air to a suitable location in the press water circulation. 4. The accumulator, as well as the remainder of the system, should be aerated and good circulation maintained in it. 5. In the event the above measures do not resolve the problem, additional germicide should be added. *(Continued on page 260)*

* Translated by W. C. Rainer, Crown Cork & Seal Co., Inc., Baltimore 3, Maryland

CARBIDE STEEL MILLING WITH CUTTING FLUIDS— A Progress Report*

by J. R. Roubik
Kearney & Trecker Corp.
Milwaukee 14, Wis.

Mr. Roubik received his B.M.E. degree in 1943 from Marquette University and has taken advanced studies at the University of Wisconsin. From 1946 to 1951 he was a Lecturer in Mechanics, Marquette University, College of Engineering, and from 1943 to the present has been engaged mainly in metal cutting research at the Kearney & Trecker Corp.

ABSTRACT: Carbide face-milling tool-life tests on four medium-carbon steels at hardnesses of approximately 200, 300, and 400 Bhn with various applications of a water-soluble oil emulsion are reported. Comparison with dry-cutting is made. Power requirements vary but slightly at any given hardness. Hardness can be used as a rough index or guide in the selection of cutting speeds and feeds. In the reported tests, application of a water-soluble oil emulsion to carbide milling of steel in any of the customary manners, and even more so with the cutter completely immersed, was not only inconvenient, but actually resulted in decreased tool life and showed no improvement in surface finish. In addition tool failure was much more likely to be of a type which is expensive to repair. These tests are part of a series which will eventually include the application of straight cutting oil.

Four medium-carbon steels were tested for tool life under different methods of application of cutting fluid at approximate hardness values of 200, 300, and 400 Bhn. Although differences in power required for the various materials at any given hardness were relatively small, as determined in previous tests[1], tool life variations were more pronounced, especially when cutting was done conventionally in still air. Attempts to attain appreciable tool life with 400-Bhn workpieces at 430 fpm cutting speed and 0.011 in. per tooth feed, the same as conditions of testing workpieces of 200 and 300 Bhn, were fruitless. Reductions in speed to 130 fpm and in feed to 0.0045 in. per tooth resulted in somewhat improved tool life.

As would be expected, greatest tool life was obtained when machining the softer materials. In all cases application of a 40:1 water-soluble oil emulsion resulted in definitely decreased tool life.

DETAILS OF MILLING TESTS

In arriving at preliminary estimates of speed and feed the hardness of steel can be and frequently is used as a rough guide. Although different materials at any given hardness show variations in tool life, these tests show that there is a significant change in the general tool-life picture at any appreciably different hardness. The tool material used in all tsets was a grade of sintered tungsten-titanium carbide which has been proven by laboratory and shop experience to be suitable for most carbide-steel milling operations.

Test bars, 1½ x 6 x 12 in., machined all over in the normalized and annealed condition from four different steels, were heat-treated to approximate hardness values of 200, 300 and 400 Bhn. The steels tested for tool life included SAE 3140, 4340, 4145, and 4145 sulphurized, see Table I.

Comparative horsepower requirements were determined with the aid of a calorimeter[2]. In such tests, 1-in.-diam. bars of the same composition and heat-treatment as the tool-life test bars were used

The test cutters for tool-life were 3-in. diameter, right-hand face mills with two solid carbide inserted blades. During the cut, however, only one blade was acting since the other had been set back in its slot approximately 1/16 in. so as not to participate in the cutting action. This was done in order to have clear and unmistakable tool life tests in terms of the number of passes per blade. From past experience it has been found, even when precautions have been taken to have all cutting edges at the same radius, that teeth in a multi-toothed cutter seldom wear exactly evenly and in such cases tool life determination cannot be as well defined or clear-cut as might be desired. It is realized that the smoothness of the cutting action with a single-toothed cutter may not be as good as with a multi-toothed cutter. However, since all tests were made by cutting with a single tooth, a basis for comparison of results exists. Blades were ground to a 12-deg. negative radial rake, 0-deg. axial rake, and 15-deg. corner angle All tests were conducted on a Kearney & Trecker 2K vertical milling machine.

The results for different materials in comparative power tests were similar for each hardness range. In power tests, cutters did not remove more than 0.3 cu. in. of material and thus there was no noticeable change in power due to tool wear[3] since the cutters could be considered essentially sharp and unworn. There is little scattering of individual data points at 200 Bhn. At 300 Bhn the same test bars require more power than at 200 Bhn, and the performances are also more erratic as indicated by the scattering of values for this hardness range. A further increase in power requirement at 400 Bhn is accompanied by a further increase in scattering.

The test bar was held in a vise which in turn was mounted within an open, 20-gallon tank that served as a chip collector and splash guard, and also a container for the cutting fluid in the immersion tests. Each material at each hardness was subjected to at least three tool-life tests under each of the following conditions: (1) Conventional cutting in still air; (2) Cutting with a 3.5-gpm. flow of 40:1 water-oil emulsion from one nozzle, directed in the direction of cutter rotation into the clearance space between the blade and work, that is, from behind the blade toward the cutting edge (See Fig. 1); (3) Cutting with a 2-gpm flow of 40:1 emulsion from each of two nozzles, one directed as above, and the other in the opposite direction, that is, impinging against the front of the blade; (4) Cutting with the cutter and workpiece completely immersed in emulsion.

The test bars at 200 and 300 Bhn were face milled at 430 fpm cutting speed, 0.011 in. per tooth feed, and 0.125 in. depth of cut. At 400 Bhn the above conditions were not practical, resulting in a tool life of only a few chips and a very undesirable type of tool failure by spalling. It was found necessary to reduce the cutting speed to 130 fpm and the feed to 0.0045 in. per tooth at 400 Bhn in order to obtain acceptable tool life.

* Sponsored by the Technical Committee on Fluids for Metal Working and presented at the 7th Annual Meeting, ASLE, Cleveland, April 9, 1952

Graphical presentations of the tool life results are given for 200 and 300-Bhn steel bars in Fig. 2 and for 400-Bhn in Fig. 3. Since the data in Fig. 3 were obtained at reduced speed and feed, Fig. 3 is not directly comparable with Fig. 2.

The test results for cutting in still air are in agreement with shop practice and indicate that in general harder steels should be milled at reduced speeds and feeds in order to obtain satisfactory tool life. Hardness, as can be seen in Fig. 2 and 3 is only an approximate indicator of machinability. Although an increase in power of about 10 percent occurs with an increase in hardness from 200 to 300 Bhn, Fig. 2 shows decreases in tool life generally from 50 to 250 percent cutting in still air or with various methods of applying emulsion. Under the same conditions of cutting speed and feed, 400 Bhn specimens showed an increase in power of about 25 percent over 200 Bhn steels and had practically zero tool life (not shown).

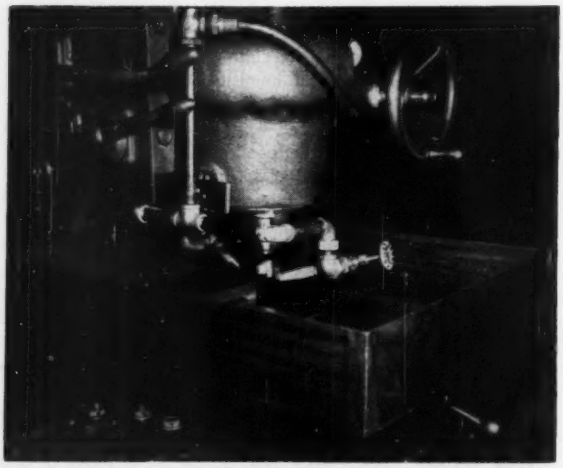


Fig. 1 Tool-life Test Setup. Starting position pictured. Nozzle on right was used in tests with cutting fluid flowing from one nozzle only. In immersion tests tank was filled with cutting fluid to within 1 or 2 inches from the top.

In tool-life tests at 200, 300, and 400 Bhn, cutting in still air in all cases was considerably superior to cutting with emulsion regardless of its manner of application. Especially surprising was the exceptionally low tool life with the cutter completely immersed in emulsion. The immersion tests were carried out not with the hope of possible future application to production jobs but for the purpose of finding out what effect completely surrounding the tool with cutting fluid would have. Although it was known that at high cutting speeds, such as prevail in grinding, cutting fluid must be properly directed to be effective, it was at first anticipated that immersion tests would show the best tool-life results rather than the worst since relatively low cutting speeds were to be used. Even if tool life had been improved by complete immersion the inconvenience of applying cutting fluid in this fashion would undoubtedly be a strong argument against such use in the shop.

At 200 and 300 Bhn, emulsion from one nozzle, with flow directed from behind the blade along the peripheral clearance face toward the cutting edge was more effective with regard to tool life than any of the other methods of application. At 400 Bhn, although there was not much variation in tool life with cutting fluids, complete immersion generally permitted slightly better tool life than did a directed flow. It should be pointed out that the ratio of maximum to minimum results in individual tool-life tests of a given type was of the order of 2:1 or less. This ratio of variation is lower than normally encountered in tool-life testing.

It can be seen in Fig. 2 and 3 that with few exceptions SAE 4145 gave better tool life than a modified, sulphurized SAE 4145 contrary to expectations. A heat-treatment (see Table I) more elaborate than usual was given the sulphurized steel with the knowledge that undissolved hard carbides would nullify the improved machining effect associated with a sulphurized steel. The sulphurized material used in these tests, despite the precautions taken in heat-treatment, did not develop the free-machining characteristics desired.

WEAR OF TUNGSTEN-TITANIUM CARBIDE BLADES

Under the most favorable conditions breakage of carbide blades will seldom occur. A rigid machine and setup, which minimize vibration and deflection, power sufficient to avoid an overload, appropriate speed and feed, and careful design, manufacture, grinding, and handling of tools are factors in obtaining good tool life without blade breakage. Nevertheless, various kinds of tool wear and failure result. Tool failure can be grouped under two broad classifications, namely, unobjectionable and objectionable.[4] Objectionable wear is that type which demands more than simple regrinding for reconditioning. If large amounts of carbide have to be removed to obtain proper blade surfaces, the expense in tool material, grinding material, and labor can seldom be justified.

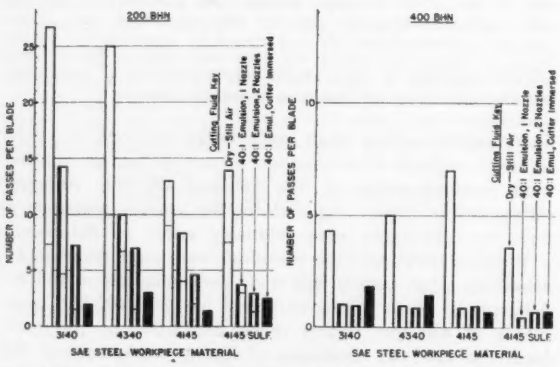


Fig. 2 (left) Average Number of Passes per Carbide Blade When Face-Milling Steel of 200 and 300 Bhn with Various Applications of Cutting Fluid. The dashed lines represent tool life at 300 Bhn. Cutting speed 428 fpm; feed 0.0112 ipt.

Fig. 3 (right) Average Number of Passes per Carbide Blade When Face-Milling Steel of 400 Bhn with Various Application of Cutting Fluid. Cutting speed 130 fpm; feed 0.0045 ipt.

A criterion of the amount of regular wear permissible before economical regrinding should take place is 1/32-in. average width of wear land on the peripheral clearance face of the blade. This criterion was used in these tests unless failure occurred in a different, objectionable manner, for example, by chipping or crumbling of the cutting edge or by spalling of carbide at or near the cutting edge (see Fig. 5).

Cutting in still air at 200 and 300 Bhn always resulted in fairly uniform wear of an unobjectionable type, while at 400 Bhn failure occasionally was of the objectionable type. With emulsion at 200 Bhn, failure was occasionally objectionable and at 300 and 400 Bhn failure was almost always objectionable, especially in the immersion tests. Whenever objectionable failure occurred it was seldom preceded by any forewarning, that is, only minute wear, usually less than 1/64 in. in width, could be seen prior to sudden chipping or spalling of the blade material.

Typical progressive wear on a tungsten-titanium carbide blade milling 300-Bhn steel in still air has been illustrated in previous publications.[1] After 9 passes, which was close to an average performance in these tests, the peripheral wear was 1/32 in. wide. Cutters whose tool-life performances are

plotted in Fig. 2 were removed for regrinding at this stage, which can be easily measured. In this condition the blade can be simply and economically reground. Beyond this point the rate of wear increases rapidly and the likelihood of chipping, spalling, and blade breakage becomes greater. The increased cost of reconditioning a blade that has worn more, or that quite frequently may have been broken or severely chipped or spalled, as a result of further use of the tool cannot be justified by the few extra passes that may be obtained. At this stage of wear the power required will have increased approximately 30 percent compared to a sharp blade. Undoubtedly, a slower cutting speed of about 300 fpm and a finer feed of about 0.006 in. per tooth would have improved tool-life performance on 300 Bhn steels. In previous tests[5] when milling mild steel under identical conditions, except for variation of the cutting speeds between 130 and 3300 fpm, the tool life of carbide tips decreased both with respect to time and amount of material removed, as the cutting speed was increased.

Figs. 4 and 5 illustrate the objectionable, expensive-to-repair type of wear frequently encountered in the tests with emulsion at 300 and 400 Bhn. Fig. 4a shows very slight chipping, and wear much less than 1/32 in. wide, while Fig. 4b shows the spalling which occurred on the same blade after only a few more seconds of cutting under emulsion. In many cases not even the small amount of wear shown in Fig. 4a could be noticed before failure, similar to that in Fig. 4b, occurred. Beside the short tool life and the undesirable type of failure occurring in these tests, visual examination of the workpiece surfaces showed no noticeable improvement in finish with the use of emulsion. These tests indicate at least that emulsion is detrimental and should not be used in carbide milling of materials similar to those reported herein.

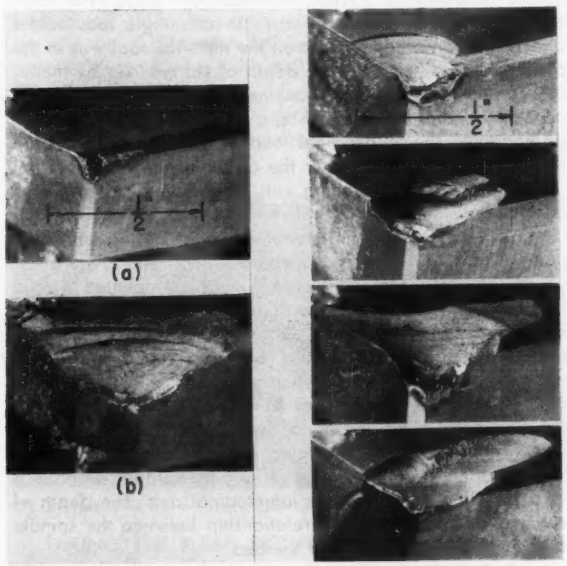


Fig. 4 (left) Typical Carbide-Blade Wear When Face-Milling 300 and 400-Bhn Steels Completely Immersed in Emulsion. (a) Slight chipping and very little peripheral wear. (b) Same blade after a few more seconds of milling.

Fig. 5 (right) Typical, Objectionable Spalling of Carbide Blades Occurring with the Use of Emulsion on 300 and 400-Bhn Steels.

RELATION TO OTHER TESTS

Previous tests[6] with high-speed steel cutters have shown that increases between 50 and 200 percent of dry-cutting tool life could be obtained with conventional application of cutting fluids. Production tests[7] on 40,000 forged steel shells when being turned with carbide brought out that a copious supply of cutting fluid, which enshrouded the workpiece, permitted a 30 percent increase in cutting speed and often as much as 10 times more production per tool. Experience in some shops has also shown that, when milling through scale with carbide blades, application of a cutting fluid resulted in improved tool life. On the other hand, in carbide milling tests on several types of stainless steel[8] better tool life performances were generally attained cutting dry than with cutting fluids. It has also been stated[9] that, for intermittent cuts with carbide tools in either turning or milling, cutting fluids are deleterious and reduce tool life. Such reductions in tool life are ascribed to frequent wide temperature changes, caused by intermittent cooling, resulting in the development of cracks (heat checks) in the carbide and eventually chipping.

TABLE I

HEAT TREATMENT OF SAE STEEL TEST BARS

Steel	Bhn	Heat Treatment[a] Heat to deg F	Quench	Draw[b] deg F
3140	202	1600	Air	——
3140	311	1550	Oil	950
3140	402	1550	Oil	750
4340	207	1475	Furnace	1225
4340	302	1550	Oil	1125
4340	402	1550	Oil	900
4145	207	1475	Furnace	1225
4145	302	1550	Oil	1075
4145	402	1550	Oil	850
4145[c]	217	1650[d]	Furnace[d]	1300[d]
4145[c]	302	1550	Oil	1150
4145[c]	402	1550	Oil	850

Key: a—All steels were first normalized and annealed. b—Cool in furnace for all steels. c—Sulphurized. d—Isothermic Anneal: Preheat at 1100 F, heat to 1650 F, furnace cool to 1100 F, reheat to 1300 F, furnace cool to 900 F, and cool in air.

Since in certain cases[10] carbide milling of workpieces at 1500 deg. F. has resulted in lower power requirements and increased tool life, heat alone near the cutting edge would not cause rapid tool failure. However, alternate heating of the blade, from cutting, and cooling, from intermittent contact with the cutting fluid, may be one of the reasons that the carbides in the tests reported herein actually showed decreased tool life with the application of fluid. Such action, if it took place, must have occurred in the vicinity of the cutting edge, although this could not be verified by visual observation during cutting operations. Outward appearances would lead one to believe that fluid was constantly in contact with the blade near the cutting edge. However, the pressure may not have been sufficiently great to insure such contact. A thin fluid stream[11] under high pressure directed into the clearance space between tool and work-piece has been found to increase tool life considerably, apparently by forcing the cutting fluid into the region in which the greatest benefit can be obtained.

The quantity or rate of flow of fluid in the tests reported herein was sufficient to engulf the machining zone at all times and the temperature of the fluid in all tests remained practically constant at room temperature. Certainly, no lubricating or friction-reducing effect was in operation. Frequently, regular wear on carbide blades exposed to a fluid during cutting had a finely pitted appearance, much rougher than the wear on blades which had been operated in still air.

CONCLUSIONS

Hardness of steel can be taken as a rough guide in establishing preliminary values of cutting speed and feed when production or tool-life tests are not available.

In milling, an increase in hardness of medium-carbon steels from 200 to 300 or 400 Bhn was generally accompanied by a small increase in energy required and a large

(Continued on page 261)

EVALUATING CUTTING OILS BY DETERMINING THEIR EFFECTIVENESS IN REDUCING SUB-SURFACE GRAIN DISTORTION*

by W. E. Lauterbach, The Albright Co.
1316 W. Lake, Chicago, Ill.
E. A. Ratzel, Midwest Research Inst.
Kansas City, Mo.

Mr. Lauterbach received his B.S. degree in Mechanical Engineering from Antioch College in 1945 and since has taken graduate work in the field of Mechanics at Illinois Institute of Technology. Upon graduation he joined the staff of Armour Research Foundation as Project Engineer, later as Ass't. Supervisor of the Materials Engineering Section. He is presently employed as Chief Engineer for The Albright Co.

Mr. Ratzel received his B.S. degree from the Illinois Institute of Technology in 1941, joining the staff of Armour Research Foundation as an Associate Engineer. Since 1948 he has been on the staff of Midwest Research Institute as a Research Engineer.

ABSTRACT: This paper presents an experimental evaluation of the effectiveness of cutting oils in reducing cold work (plastic flow). X-ray diffraction is used as a laboratory tool to measure the depth of the distorted grain structure in steel specimens which were planned under a variety of conditions. Basic relationships for the depth of cold work as affected by rake angle, depth of cut, and cutting speed are obtained for dry cutting and cutting with five oils. As expected, the depth of cold work decreases with increasing rake angle and increases with increasing depth of cut. Any one of the five oils reduced the depth of cold work as compared to dry cutting. However, only at a low cutting speed (2.5 fpm) are significant differences obtained between the five oils. At a higher cutting speed (75 fpm) there is no measurable difference between two oils.

A comparison of the experimental evaluation of the oils is made with an independent field rating. The largest depth of cold work accompanies the least effective oil and the smallest depth of cold work is found with the most effective oil.

It is concluded that depth of cold work determinations afford a laboratory method of evaluating cutting oils which are to be used in low-speed machining operations.

PURPOSE OF EXPERIMENTATION

The objectives are (1) to determine the relationship between depth of cold work and each of three variables—rake angle, depth of cut, and cutting oil, and (2) to ascertain the potential value of x-ray diffraction analysis for depth of cold work as a laboratory method for evaluating cutting oils.

X-RAY DIFFRACTION AS A TECHNIQUE FOR DETERMINING DEPTH OF COLD WORK

The depth of cold work produced in a workpiece by a machining operation can be determined by the application of x-ray diffraction analysis[1,2]. Briefly, the success of this technique is based on the following phenomena: When a collimated x-ray beam is directed normal to a flat, annealed steel specimen, the x-rays are reflected from the individual grains which lie in a surface layer of less than 0.001 in. in depth. The reflected x-rays will produce a ring of clearly defined spots on x-ray sensitive film, as shown in Fig. 1a. However, reflected x-rays from a severely cold-worked surface, in which the original grain structure has been distorted plastically will yield a totally diffused ring, as pictured in Fig. 1d. Figures 1b and 1c show reflection patterns corresponding to surfaces with intermediate degrees of grain structure distortion. Hence, it is possible to define the depth of cold work as the "distance below the surface at which the effect of grain structure distortion is no longer apparent in an x-ray diffraction photograph."

* From an investigation sponsored by the Shell Oil Co. at Armour Research Foundation, Chicago, Illinois

By the repetitive process of etching away a definite thickness of a cold worked surface and then taking an x-ray diffraction photograph, characteristic patterns are obtained for given increments of depth below the original machined surface. The depth of cold work is determined by noting when two consecutive photographs show diffraction patterns in which the rings consist of clearly defined spots.

EXPERIMENTAL SET-UP FOR MACHINING TEST SPECIMENS

Two experimental arrangements were employed for preparing the test specimens, both of which made possible a two-dimensional planing operation.

A milling machine was adapted for the low-speed planing operation. The work pieces were 3/16 in. thick rectangular plates of SAE X1025 annealed steel which were held on edge as shown in Fig. 2. The cutting tools were high-speed steel, 3/8 in. square by 3 in. long, ground on one end to a square nose with a 55-deg. included tool angle. The tools were clamped in a special variable-rake-angle tool holder attached to an arbor support on the mill. The tool was in the plane of the workpiece. The depth of cut was set by manually raising the bed of the machine a given amount as determined by a dial indicator. Thus, a test cut was accomplished by engaging the longitudinal feed of the mill which caused the workpiece to pass under the center of the fixed tool.

For higher-speed planing cuts, the milling machine was adapted for a simulated planing operation as shown in Fig. 3. The workpieces were tubular shapes of either annealed SAE 1020 steel or spheroidized-annealed SAE 52100 steel, which were grasped in a three-jaw chuck mounted on the spindle of the machine. The cutting tools were high-speed steel, 3/8 in. square by 1 in. long, ground to a square nose on one end so as to produce a rake angle of 10 deg. and a clearance angle of 5 deg. when mounted on the bed of the mill. The straight cutting edge of the tool was positioned on the horizontal diameter of the workpiece. Thus, a test cut was accomplished by engaging the cross feed of the mill which caused the tool to advance into the rotating workpiece in a direction parallel to its longitudinal axis. The depth of cut was determined by the relationship between the spindle speed and the cross speed of the bed.

TEST PROCEDURE

MACHINING THE TEST SPECIMENS: Prior to each test cut, the surface of the workpiece was prepared by making a long series of cuts with decreasing depths, to a final finishing cut of 0.0001 in. This procedure was followed to insure a minimum depth of cold work. A newly sharpened tool was employed for each test cut.

A large number of low-speed (2.5 fpm) test cuts were made with and without cutting oils (the cutting oils used in these tests were supplied by Shell Oil Co. and are designated by code numbers in the presentation of results), at

depths of cut ranging from 0.0019 to 0.0032 in., and with rake angles between 3.5 and 30.5 deg. A small test specimen, approximately 3/4 in. by 3/4 in., was sawed from the corner of the flat workpiece after each test cut. This made it possible to produce several test specimens from one workpiece. The sawed edge opposite the planed edge of each specimen was surface-ground parallel to the planed edge to facilitate micrometer caliper measurements which are discussed later.

Several high-speed (75 fpm) test cuts were made with and without cutting oils at a depth of cut of 0.0023 in. In order to obtain equilibrium conditions, the duration of each test cut was maintained at exactly 1/2 min. after which time the cut was stopped abruptly. Small test specimens could not be sawed from the workpiece since this would produce a discontinuous surface for subsequent test cuts. Consequently, the depth of cold work was determined on each of several tubular workpieces, some of which were then employed for additional test cuts.

ETCHING THE TEST SPECIMENS: Metal was removed from the planed (cold-worked) surface of each test specimen by controlled etching in a weak nital solution. Metal removal between x-ray photographs taken on the same specimen was usually large at first, but was decreased to approximately 0.005 in. per etch when the undisturbed annealed steel was approached.

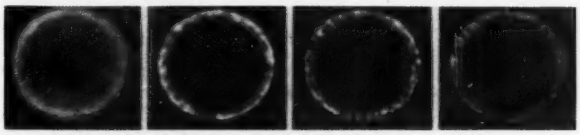


Fig. 1 Typical x-ray diffraction photographs

MEASURING THE DEPTH OF ETCH: The depth of etch of each small plate specimen was determined by measuring the change in dimension between the planed edge and the parallel ground edge with a 0.0001 in. micrometer caliper. The depth of etch of the tubular specimens was measured directly by placing each specimen, planed end up, on a horizontal surface plate under a vertically mounted 0.0001 in. dial indicator.

Fig. 2 Test setup for low-speed planing

TAKING THE X-RAY PICTURE: A General Electric XRD unit, employing a CA-5 tube with a cobalt target, and General Electric x-ray film, were used for taking the pictures. The exposure time varied from 5 to 12 min. (depending on the workpiece material) at a voltage of 20 kv and a current of 12 ma. The distance between the planed surface of the test specimen and the film was maintained at exactly 5 cm.

The small plate specimens were mounted in the standard specimen holder of the x-ray machine, as illustrated in Fig. 4 (Figs. 4 and 5 are adaptations of a sketch shown in General Electric XRD Unit Laboratory Handbook—Directions No. 11124). The tubular specimens were held in a special fixture which was attached to the camera track, Fig. 5. In both cases, care was taken that the x-ray beam would strike the surface of each specimen at exactly the same location after each successive etching operation.

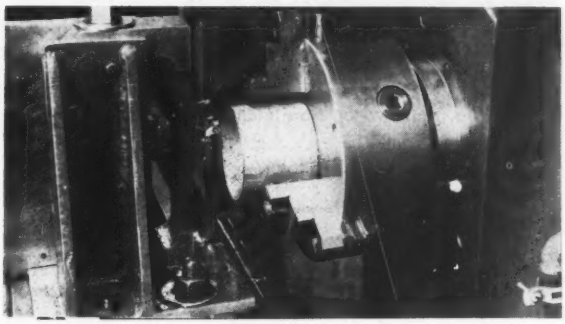


Fig. 3 Test setup for high-speed planing

RESULTS AND CONCLUSIONS

REPRESENTATIVE X-RAY DIFFRACTION PHOTOGRAPHS: Figs. 6 and 7 are reproductions of several typical series of x-ray diffraction photographs obtained from flat-plate specimens and tubular specimens, respectively. Each vertical column of photos shows a series of patterns corresponding to successive depths of etch on one given test specimen. The number at the upper left in each photo denotes the cutting oil code number; the number at the upper right gives the depth of etch in 0.0001 in. The pictures designated with an "X" represent the first of two consecutive pictures in each series which show similar patterns with clearly defined spots.

For convenience, the "X" marked picture in each series is termed the "first clear picture" and the picture immediately preceding it is termed the "last cloudy picture." It is apparent that the depth of cold work for each test specimen is somewhere between the depth of etch corresponding to the last cloudy picture and the depth of etch corresponding to the first clear picture.

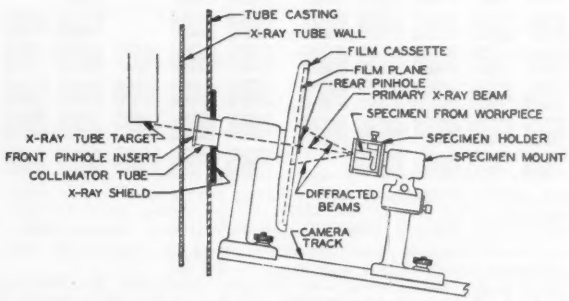


Fig. 4 Test setup for taking x-ray diffraction photographs of flat plate specimens

RELATIONSHIP BETWEEN DEPTH OF COLD WORK AND RAKE ANGLE: Curves plotted from the experimental data show that the depth of cold work decreases linearly with increasing rake angle when cutting at 2.5 fpm; the slopes of the curves vary from -0.62×10^{-4} in./deg. for cutting with oil No. 6 to -1.25×10^{-4} in./deg. for cutting dry.

Fig. 8 presents six individual graphs in which the depth of cold work is plotted against rake angle for cutting dry and for cutting with five different cutting oils. A composite graph of these data is shown in Fig. 9. These results were obtained from specimens planed at a speed of 2.5 fpm and at a depth of cut of 0.0020 in. $\pm$0.0001 in. In Fig. 8, the results obtained from each test specimen are represented by two short horizontal lines connected by a vertical line; the lower horizontal line is the depth of etch of the last cloudy picture and the upper horizontal line is the depth of etch of

the first clear picture. The actual depth of cold work lies somewhere on the vertical connecting line. The small circles which appear on several of the vertical lines denote that these particular data were obtained from the series of x-ray diffraction pictures reproduced in Fig. 6. Very good reproducibility of test results was experienced in these tests as evidenced by the several experimental points in Fig. 8, where data from two or more identical tests are plotted.

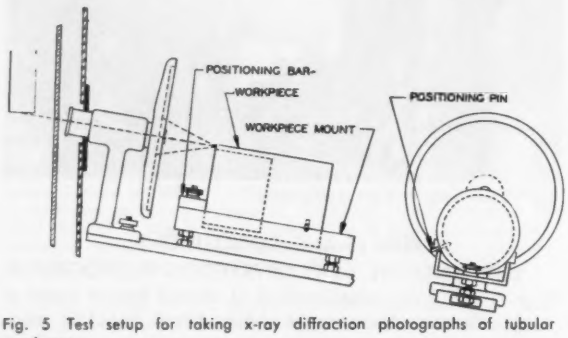


Fig. 5 Test setup for taking x-ray diffraction photographs of tubular specimens.

RELATIONSHIP BETWEEN DEPTH OF COLD WORK AND DEPTH OF CUT: Curves plotted from the experimental data show that, within the range of the tests, the depth of cold work increases with increasing depth of cut when cutting at 2.5 fpm. For example, when cutting dry, depth of cold work is approximately 2.3 times the depth of cut.

In Fig. 10, the depth of cold work is plotted against depth of cut for cutting dry and for cutting with two different oils at a speed of 2.5 fpm and with a rake angle of 30.5 deg. The two experimental points represented by circles were obtained by extrapolation from the appropriate curves in Fig. 8.

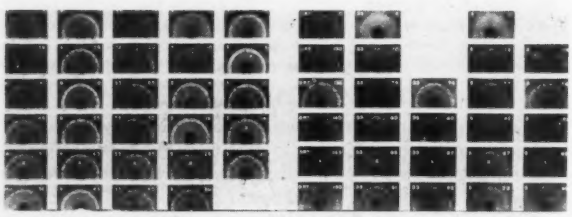


Fig. 6 (left) Representative x-ray diffraction photographs from flat plate specimens (Work material: SAE X1025 annealed, cutting speed: 2.5 fpm, depth of cut: 0.0020 ± 0.0001 in., rake angle: 21 deg., clearance angle: 14 deg. Numbers at upper left denote cutting oil code number and numbers at upper right give depth of etch in 10^{-4} in.)

Fig. 7 (right) Representative x-ray diffraction photographs from tubular specimens (Work material: SAE 1020 annealed, cutting speed: 75 fpm, depth of cut: 0.0023 in., rake angle: 10 deg., clearance angle: 5 deg. Numbers at upper left denote cutting oil code number and numbers at upper right give depth of etch in 10^{-4} in.)

RELATIONSHIP BETWEEN DEPTH OF COLD WORK AND CUTTING OIL: Curves plotted from the experimental data show that the depth of cold work for cutting with any one of five different oils at a given rake angle is significantly less than the depth of cold work for cutting dry at the same rake angle. This is true for either 2.5 fpm or 75 fpm. However, for a cutting speed of 2.5 fpm, appreciable differences in the depth of cold work are apparent for cutting with each of the five oils, but for a cutting speed of 75 fpm, no measurable differences in the depth of cold work are apparent for cutting with each of two different oils.

From Figs. 9 and 10, which present results of the tests conducted on the flat-plate workpieces at a cutting speed of 2.5 fpm, it is found that the reduction in cold work from that produced by a dry cut varies from 26 per cent for cutting with oil No. 9 to 67 per cent for cutting with oil No. 3, both at a rake angle of 21 deg. At a rake angle of 30 deg., the reduction varies from 30 per cent for oil No. 9 to 84 per cent for oil No. 3.

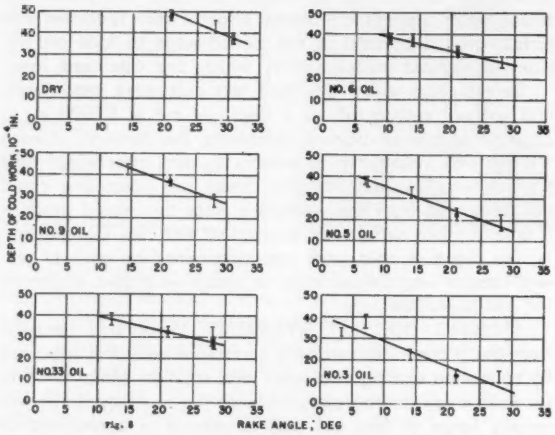


Fig. 8 Relationship between depth of cold work and rake angle (Test specimen: flat plate, work material: SAE X1025 annealed, cutting speed: 2.5 fpm, depth of cut: 0.0020 in., clearance angle: 35 deg. minus rake angle. The small circles designate test data obtained from x-ray diffraction photographs shown in Fig. 6)

Fig. 11 presents results of the tests conducted on the tubular workpieces at a cutting speed of 75 fpm and a depth of cut of 0.0023 in. The bottom of the shaded area on each bar represents the depth of etch of the last cloudy picture and the top of the shaded area represents the depth of etch of the first clear picture. Thus, the actual depth of cold work falls within these two limits. The small circles on several of the bars indicate that these data were obtained from the

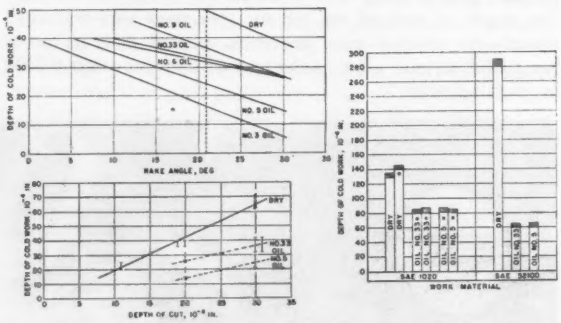


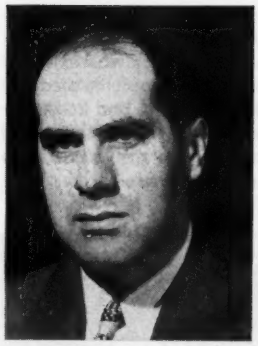
Fig. 9 (upper left) Relationship between depth of cold work, rake angle, and cutting oil (Composite of individual curves shown in Fig. 8)

Fig. 10 (lower left) Relationship between depth of cold work, depth of cut, and cutting oil (Test specimen: flat plate, work material: SAE×1025 annealed, cutting speed: 2.5 fpm, rake angle: 30.5 deg., clearance angle: 4.5 deg. The experimental points represented by circles were obtained from appropriate curves in Fig. 8)

Fig. 11 (right) Relationship between depth of cold work and cutting oil (Test specimen: tubular, cutting speed: 75 fpm, depth of cut: 0.0023 in., rake angle: 10 deg., clearance angle: 5 deg. The small circles designate test data obtained from x-ray diffraction photographs shown in Fig. 7)

series of x-ray diffraction photographs given in Fig. 7. The recorded data from duplicate tests again illustrate the good reproducibility of results that was attained. An examination of the data shown in Fig. 11 reveals that the depth of cold work for cutting with either oil No. 5 or oil No. 33 on SAE 1020 annealed steel is about 40 per cent lower than the depth of cold work for cutting dry. Similarly, the depth of cold work for cutting with either of the oils on SAE 52100

(Continued on page 261)



NACA STUDIES OF MECHANISM OF FRETTING (FRETTING CORROSION) AND PRINCIPLES OF MITIGATION*

by D. Godfrey and E. E. Bisson
NACA, Lewis Flight Propulsion Lab.
Cleveland 11, Ohio

Mr. Godfrey was awarded a B.S. degree in Chemical Engineering by the University of Utah in 1942. Following service in industry and the Air Force he joined the research staff of NACA at Lewis Flight Propulsion Lab. in 1944 and served successively as Research Engineer and Project Engineer in the Lubrication and Wear Section. His research has primarily been directed toward determination of basic mechanisms of various friction phenomena, the results of which have been published in a number of NACA reports. Recently the nature and utilization of solid film lubricants has been the object of his research activity.

Mr. Bisson attended the Universities of Vermont and Florida, receiving his B.S. degree in Mechanical Engineering from the latter in 1938. He joined NACA at Langley Field in 1939 and served successively as Research Engineer and Project Engineer; in 1943 he was transferred to NACA's Lewis Flight Propulsion Lab. as Head of the Piston Ring and Cylinder Barrel Research Section, in 1945 being named Head of the Lubrication, Friction, and Wear Research Section. At present he is the NACA representative on the Co-operative Research Council's group on Aircraft Gas-Turbine Engine Bearings and Their Lubricants, and a member of the NACA Sub-committee on Lubrication and Wear.

ABSTRACT: An experimental investigation, using microscopic observation and color motion photomicrographs of the action, was conducted to determine the mechanism of fretting. Glass and other non-corrosive materials, as well as metals, were used as specimens. The observations and analyses led to the conclusions that fretting is caused by the removal of finely divided and apparently virgin material due to inherent adhesive forces between the surfaces. The fretting of non-corrosive materials indicates that oxidation as a cause is a secondary rather than a primary factor. Studies of methods of inhibition of fretting indicate that MoS_2 can be quite effective in delaying the start of fretting if the coating of MoS_2 is properly applied. MoS_2 is particularly effective because of its capability of reducing metallic adhesion at the contact areas.

INTRODUCTION

Fretting, defined as surface failure that may occur when closely fitting metal surfaces experience slight relative motion, damages many machine parts subject to vibration. The phenomenon of fretting (also known as fretting corrosion and friction oxidation) is principally characterized by surface stain, pitting, and the generation of oxides, as described in detail in Ref. 1 and 2.

Fretting occurs in aircraft engines particularly on the tooth surfaces of the main shaft coupling and on the gear keys and shafts. In fact, any clamped, bolted, or press fit surface is susceptible. These parts are designed to be stationary, but relative vibratory motion is often unavoidable. Rolling contact bearings are particularly susceptible at the surface between inner race and shaft and the surface between outer race and housing. Any bearing which is subject to rotational oscillation and side thrust vibration, such as blade bearings on helicopters, has a very short life due to fretting.

Fretting results in functional failure, replacement of the part, a decrease in the time between overhaul, and occasionally complete part failure. Further, fretting increases susceptibility to fatigue-failures of dynamically loaded machine components.

Factors which apparently influence fretting are motion, oxygen, lubrication, hardness, load, materials and surface roughness. Relative slip (motion) of the contacting surfaces is necessary to cause fretting. Relative motion, particularly of small amplitude, between the two parts does not necessarily mean slip between the contacting asperities however. Slip as small as one-millionth of an inch has been shown to produce fretting.[2] Fretting debris is composed of oxides of iron suggesting that the concentration of oxygen may be important for the propagation of fretting. Lubrication delays, but does not prevent, fretting. The proposal has been made that lubricants serve to exclude oxygen. Often designers specify increasing hardness of metals and increasing load to minimize fretting. This practice has been most successful when the load between two surfaces was great enough to prevent motion. No materials, including many non-metals, have been found to be free of fretting.

Tomlinson suggests[2] a theory of molecular attrition that proposes that the cause of fretting is a physical action, or specifically that the disintegration of the metal surface is due to "molecular plucking." More recently, chemical action has been reported to be of primary importance.[3] Other investigators[1,4] have advanced electrolytic, abrasion, welding, fatigue, and "vibrational decay" theories to explain the action that produces fretting. These theories are incompatible or divergent and more experimental evidence is needed before any one of them may be generally accepted.

The theories of molecular attrition, surface welding, vibrational decay, fatigue and abrasion suggest that the cause of fretting is a physical action, and the theories of electrolytic corrosion and friction oxidation suggest fretting is caused by a chemical action. The divergence in the theories may be resolved simply to the sequence of the events; namely, physical action suggests that material is rubbed off the surface and then oxidized, chemical action suggests the surface is first oxidized or corroded and the oxides are then rubbed off.

The NACA research on fretting herein described was conducted at the Lewis Flight Propulsion Lab. and reported in detail in Ref. 5 and 6. The purpose of the first part of the research was to observe and analyze the action of fretting in its initial stages. The purpose of the second part was to investigate the principles of mitigation or prevention. Inasmuch as the limits of mechanical variables such as load, frequency, and amplitude have been established,[2] the first part of the investigation was limited to microscopic observation, debris analysis, and surface analysis of fretting areas. The non-metallic and non-corrosive materials, glass, quartz, ruby, and mica, and the metal platinum were used as specimens because their fretting would indicate whether the primary action was physical or chemical; in addition, the non-metallic materials simplified the debris analysis, and in some cases permitted microscopic observation or color motion photomicrographs of the action.[7] The motion photomicrographs taken in color describe fretting more effectively than words or black-and-white photomicrographs.

Fretting was induced by a very simple apparatus (described below) which vibrated a convex (usually spherical)

* Sponsored by the Technical Committee on Lubrication Fundamentals and presented at the 7th Annual Meeting, ASLE, Cleveland, April 9, 1952

surface in contact with a flat surface at frequencies of 120 cycles or less than 1 cycle per second, an amplitude of 0.001 inch, and a load of 0.2 pound.

APPARATUS, MATERIALS, AND PROCEDURE

A schematic diagram of the apparatus is shown in Fig. 1. The vibrating action of 120 cycles per second with an amplitude of 0.001 inch was induced by a solenoid. A ½ inch chrome steel ball was firmly attached to the plunger of the solenoid, which was horizontal. A flat specimen was held stationary at one end and loaded vertically by a flat spring. The spring caused the flat to exert a load of approximately 0.2 pound on the ball.

The apparatus could be attached to the mechanical stage of a microscope, which permitted microscopic observation at 140 magnification of the contact area with vertical or oblique illumination. With transparent flat specimens, the contact area could readily be located because it was surrounded by concentric interference bands.

A group of experiments that are considered to be ½-cycle experiments were conducted with an adapter on the apparatus, which provided for sliding the glass microscope slide over the surface of the stationary ball at a speed of approximately 0.002 inch per second or less. The motion was caused

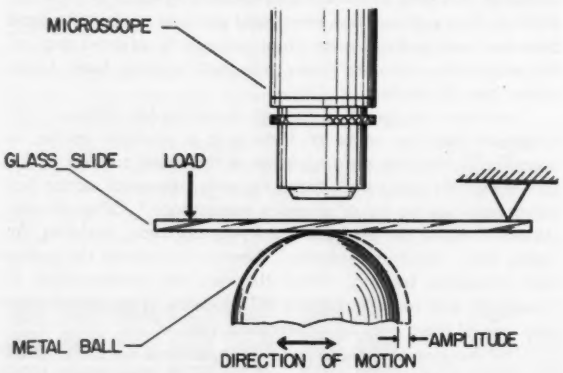


Fig. 1 Schematic diagram of fretting apparatus

by hand-turning a fine screw to which the glass was attached. The direction was reversed each 0.001 inch, and the frequency was considered 1 cycle per second or less. A slow-motion vibration was thus simulated and the action that occurs in ½ cycle was observed.

All specimens were thoroughly cleaned immediately before being mounted in the apparatus. The metal cleaning consisted in degreasing in an organic solvent followed by scrubbing with surgical cotton in a paste of levigated alumina, a thorough rinse in tap water, a rinse in 95-percent alcohol, and drying in air. Particular effort was made to wash off all adhering alumina. Glass, ruby, quartz, and mica specimens were cleaned in fresh acid-cleaning solution followed by rinse in tap water and distilled water and oven drying.

RESULTS AND DISCUSSION

Preliminary experiments showed that the fretted spot on metal caused by vibrating it in contact with glass was very similar to that formed in metal-metal combinations.

STEEL VIBRATING IN CONTACT WITH GLASS: Photomicrographs of the contact area at various stages of the fretting caused by vibrating a chrome-alloy steel ball against a glass specimen are shown in Fig. 2. Within ¼ second (30 cycles), fretting was evident as a small black irregular spot on the ball, which steadily grew in size and became discontinuous (Fig. 2a and 2b). A brown, sticky semifluid oxide was then generated within the contact area, spread over the glass, and adhered tenaciously to it. This oxide shares the contact area with the black material (Fig. 2b and 2c). A rust-colored fine dry oxide was also formed that was extruded from the area in increasing quantities and accumulated just outside the rubbing area, as evident in Fig. 2b and 2c. Active black spots shifted position as the phenomenon progressed because of disintegration of peaks bearing the load for the moment. Color motion photomicrographs were taken of this action[7].

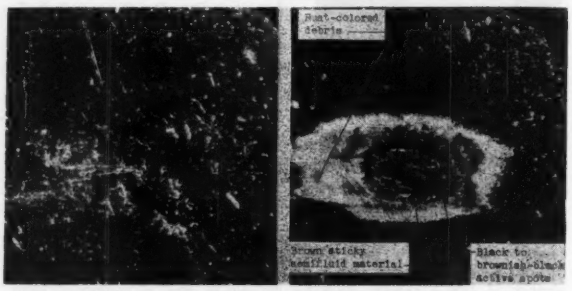


Fig. 2a (left) Photomicrograph showing progressive stage in fretting between glass microscope slide and steel ball. X140. Cycles, 30

Fig. 2b (right) Photomicrograph showing progressive stage in fretting between glass microscope slide and steel ball. X140. Cycles, 120

After approximately 40,000 cycles, the action stabilized to a steady-growth condition with continued generation of material in the black spots surrounded by brown semifluid oxide and the formation of fine powder-like oxide. The black color of the active areas indicated the presence of finely-divided iron; this indication was further confirmed by subsequent change to dark brown and then to rust brown. If the vibration was stopped, the trapped black material could be seen to turn brown gradually. Finely-divided iron, ferrous oxide FeO, and ferrosoferric oxide Fe_3O_4 are black, whereas feric oxide Fe_2O_3 and its hydrated form $Fe_2O_3\ H_2O$ are reddish. The fretting debris of steel was identified by electron diffraction as Fe_2O_3 and the color changes that occurred suggest the progressive oxidation of the iron. Fretting is apparently initiated by the loosening, due to inherent adhesive forces, of extremely finely divided and apparently virgin material that is extruded and reacts with oxygen simultaneously. Examination of the ball after the experiment revealed a flat oxide-encrusted spot which on subsequent cleaning was revealed to be an abraded flat spot. The sticky oxide on the glass was removed with difficulty but completely with acids, and a striated cracked area was revealed.

PLATINUM VIBRATING IN CONTACT WITH GLASS: Results obtained when platinum was vibrated against glass slides supported the explanation of fretting deduced from the steel-glass experiments. In one experiment, flame-cleaned platinum foil, partially wrapped around and supported by a steel ball, was vibrated in contact with clean glass. The generation of a black powder in the characteristic way was observed. This powder remained black and that which adhered to the glass could be completely removed only by a 4-hour treatment in aqua regia. Color, acid resistance, electron-diffraction patterns, and source indicated that the material was finely divided platinum (platinum black). Because platinum will not oxidize in air at any temperature, the theory that oxidation is a primary cause of fretting is not supported.

COMBINATIONS OF NON-METALLIC, NON-OXIDIZING MATERIALS: The independence of fretting from chemical action was indicated in a group of experiments involving the non-metallic, non-oxidizing materials with glass vibrated against quartz, ruby, or mica. By vibrating a ruby with a convex surface against a glass slide and observing the action under a microscope, surface disintegration could be seen to occur. The glass, after 2 to 3 seconds of rubbing, suddenly

collapsed locally and distributed debris about the contact area, leaving a pit. The ruby was simply further polished, that is, the microscopic scratches were erased. Quartz against glass acted the same as ruby against glass. Mica against a glass ball and Lucite against a glass ball also behaved similarly. In all cases, the debris was produced, extruded, and accumulated in the same physical manner observed with metal debris, except that no change in color took place.

HALF-CYCLE EXPERIMENTS: Under the conditions of the ½-cycle experiment the glass would polish the contact area on the ball and become smeared with the semifluid oxide, which again, would tenaciously adhere to the glass. If a ball with a highly polished contact area was used much less oxide would be smeared, but the movement would cause the glass to grip or adhere to the ball and as relative motion continued the glass would visibly and audibly crack. A photomicrograph of the glass in the process of forming a second crack is shown in Fig. 3. A row of cracks was produced in the glass during continued sliding. The smearing of the metallic oxide onto the glass and the cracking of the glass are apparently due to the great amount of adhesion permitted by the extreme cleanness of the specimens. Inasmuch as debris and surface damage occurred in ½ of one cycle of vibration, surface fatigue is not a contributing factor in initiating fretting. Further, alternation of direction of motion is not necessary to initiate fretting although alternation does give the phenomenon its usual characteristics.

Adhesion has been shown[8] to be a component of the frictional phenomenon. Inasmuch as the actions observed in this research namely, removal of material, cracking, and general surface destruction are attributed to dhesion, the basic mechanism of fretting is dependent upon adhsion and therefore becomes a part of frictional phenomena.

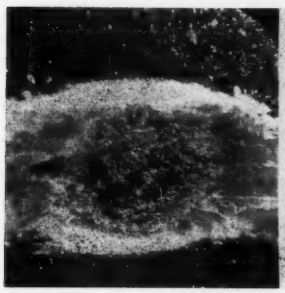


Fig. 2c (left) Photomicrograph showing progressive stage in fretting between glass microscope slide and steel ball. X140. Cycles, 720
Fig. 3 (right) Photomicrograph showing effects of one-half cycle vibration between glass and steel surface. X140

Therefore, it is becoming evident that fretting is a problem of friction or of concentrated and severe wear and all the theories and results of friction are applicable. In fact, fretting exerts a super cleaning action on the materials, leaving them susceptible to accompanying high coefficients of friction, severe metal transfer and general surface failure.

Motion photomicrographs are available[7] which describe more effectively than words or still photomicrographs the action of fretting. These color motion photomicrographs are available as an NACA Technical Film and can be obtained on a loan basis.

MITIGATION OF FRETTING

Inasmuch as the results indicated that fretting is caused basically by the removal of virgin material due to high adhesive forces the inhibition or mitigation of fretting should result from any means which produces a decrease in the adhesive forces. The insertion of any low-shear-strength film (either liquid or solid) between the surfaces has been shown to decrease adhesion and friction. The chief problem becomes one of maintaining an effective film between the fretting surfaces. Maintenance of an effective liquid film is very difficult, because of the severe "scrubbing" effect on very small areas of the fretting action. Since the amplitude is also quite limited there is very little likelihood that the contact areas will have a chance to be "rewet" by the liquid. In consequence. liquids are limited in their effectiveness as fretting inhibitors.

Maintenance of an effective solid film is dependent entirely on the toughness of the film and its tenacity for one or both of the fretting surfaces. The effectiveness of the solid film is a function of its low shear strength and its ability to decrease the forces of adhesion.

Molybdenum disulfide is a solid film lubricant possessing the following desirable properties: high load carrying capacity and capability of minimizing metallic adhesion under high pressures[9], tenacity for steel, and low friction coefficients over a wide range of velocities[10], and thermal stability[11]. MoS_2 was therefore chosen as a possible fretting inhibitor of promise and an investigation was conducted to determine its effectiveness.

As in the microscopic investigation, experiments were conducted with the steel ballglass flat apparatus at a frequency of 120 cycles per second, an amplitude of 0.001 inch and a normal load of 0.2 pound. Experiments were also conducted with steel flats vibrating against steel flats at a frequency of 15 cycles per second, an amplitude of approximately 0.003 inch and a nominal pressure of 20 pounds per square inch.

The effectiveness of a number of methods of applying MoS_2 were evaluated in both types of apparatus. The number of cycles to failure was determined in both cases as the point at which incipient fretting damage was observed. The first appearance of debris or brown stain (indicating the presence of oxides) was taken as evidence of fretting in his investigation. All specimens were thoroughly cleaned prior to application of MoS_2 by degreasing and successive washes in an uncontaminated solvent of acetone-benzene.

MoS_2 was applied in a number of ways, of which only two wiwll be discussed in detail in this paper. These were: (1) dusting of dry MoS_2 on clean surfaces, (2) application of a bonded MoS_2 film in accordance with the following procedure: (A) Thoroughly clean and degrease specimen, (B) Heat specimen (steel) until oxide film is dark blue, (C) Apply a mixture of MoS_2 in a resin-forming, liquid vehicle (glycerine, for example) to the hot specimen and bake until dry, (D) Remove excess mass of film to leave a smooth, thin, uniform film.

The results of the investigation of mitigation or inhibition of fretting is shown in Table I. The degree to which each method inhibits fretting is indicated by the number of cycles required for the occurrence of the phenomenon. The number of cycles is an average of 3 duplicate experiments and the reproducibility was usually better than plus or minus 10 per cent (actually plus or minus 3 per cent in most cases). For comparison with the MoS_2 films, results of experiments with both clean specimens and specimens lubricated with mineral oil are included.

TABLE I
EFFECTIVENESS OF MOLYBDENUM DISULFIDE AS A FRETTING INHIBITOR

Steel ball against glass flat	No. of cycles for fretting
Clean	1-30
Mineral oil	1500
MoS_2 dusted	72,000
MoS_2 bonded	28,000,000
Steel flat against steel flat	
Clean	<100
MoS_2 bonded	10,000,000

(Continued on page 262)

FUNDAMENTAL KNOWLEDGE OF LUBRICATING GREASE STRUCTURE*

by B. W. Hotten
California Research Corp.
576 Standard Ave.
Richmond, Calif.

Dr. Hotten graduated from the University of Cincinnati in 1941 with a B.A. degree and from Purdue University in 1945 with a Ph.D. degree, with major studies in organic chemistry. He spent an additional year at Purdue as a postdoctorate fellow doing research on organic fluorine compounds. Since 1946 he has been a research chemist at California Research Corp. where he has studied the formulation and fundamental properties of lubricating greases.

ABSTRACT: The composition and functional requirements of greases are briefly described. Theories of the physical structure of greases are discussed and recent evidence in favor of the microcrystalline paste theory is presented in detail. The variation of fiber structure with thickener composition is shown in electron micrographs. Changes in structure with temperature are described. Finally the relation between colloidal structure and flow properties is described. Correlations between structural and functional properties of lubricating greases are pointed out wherever applicable.

The value of lubricating greases in service depends to a large extent on their physical structure. Within the last ten years much progress has been made toward the elucidation of this structure.

This paper describes some of the most interesting and useful information obtained in recent years concerning the relationship which occur between preparative variables and fine structure, and in turn between fine structure and gross physical and functional properties of lubricating greases.

PREPARATION OF LUBRICATING GREASES

COMPOSITION: Lubricating greases contain three major components: lubricating oils, thickening agents, and additives. Examples of the most frequently used lubricating grease components are: Oils—naphthenic and paraffinic petroleum oils, esters and polyethers (aircraft lubrication), polysiloxanes (high heat resistance); Thickening Agents—lithium, sodium, calcium, strontium, barium, and aluminum soaps, carbon black, fine silica, alkylammonium bentonites; Additives—dispersants (water, glycerine, alcohols), fillers (graphite, white lead, zinc oxide), stringiness agents (rubber, polybutenes), film strengtheners (sulfur and chlorine compounds, tricresyl phosphate), anti-oxidants (aromatic amines, phenols, sulfur and selenium compounds), anti-corrodants (amines, sulfonates).

MANUFACTURE: When soaps are used as thickening agents they may be either preformed or they may be formed in the oil from fats or fatty acids and bases. Aluminum soaps and sometimes lithium soaps are preformed. Sodium and calcium soaps are more often formed in the oil. Dispersion is accomplished most commonly by either of two methods: (1) The soap is heated in the oil until it dissolves, the solution is then cooled to form a gel, and the gel is milled to form a smooth grease; or (2) the soap is formed in the oil and dispersed by means of stirring, usually with only moderate heating so that the soap dissolution temperature is not reached.

Oil-insoluble thickeners, such as acetylene black, alkylammonium bentonite. or fumed silica, may be dispersed simply by milling in oil at room temperature to form greases, although elevated temperatures may be used with these thickeners also.

* Sponsored by the Technical Committee on Lubrication Fundamentals and presented at the 7th Annual Meeting, ASLE, Cleveland, April 8, 1952

FUNCTIONAL PROPERTIES

CONSISTENCY: The solidity of grease under static conditions enables it to stay in place even in unsealed bearings and on open gears and helps it to prevent dirt and water from coming into contact with parts being lubricated. The fluidity of grease under stress, as in a rotating bearing, enables it to flow over the surfaces requiring lubrication.

TEXTURE: Smooth texture facilitates operation of high-speed bearings and of equipment being used at very low temperatures. Fibrous or stringy texture is advantageous in low-speed bearings as an aid to feeding and to cushion against shocks.

HEAT RESISTANCE: Consistency and texture should not change excessively with temperature. Aluminum and hydrated calcium soap greases are generally not useful above 200 F. Lithium and sodium soap greases are often useful up to about 300 F. Both phase changes and oxidation limit the use of greases at elevated temperatures.

WATER RESISTANCE: Grease should not wash out of the part being lubricated when it is splashed with water. It should also prevent rusting. Lithium, calcium, and aluminum soap greases have good water resistance. Sodium soap greases have poor water resistance, but they inhibit rusting even when present in thin layers.

FINE STRUCTURE

Several theories of the state of dispersion of greases have been proposed in the past. States postulated include solution, emulsion, gel, liquid crystal, and paste.

MICROCRYSTALLINE PASTE STRUCTURE: At present, experimental evidence favors the view that the thickening agent in a grease is dispersed in the form of a very fine paste. The solid particles form a three-dimensional network which gives the mixture rigidity despite the presence of 70-90% fluid oil in the system.

Greases lack typical properties of solutions, emulsions, and true gels except at elevated temperatures. The fact that the oil can be removed from the thickener matrix and then replaced, with reattainment of the original structure, as has been demonstrated by Browning[3], shows a definite two-phase character. Examination of greases by means of x-ray diffraction by Vold, Hattiangdi, and Vold[9] indicates that the process of dispersing soap in oil does not change its crystal structure. The most conclusive evidence is obtained by direct observation of greases under the electron microscope as has been done by Birdsall and Farrington[1,4].

VARIATION OF FINE STRUCTURE WITH COMPOSITION: The electron microscope reveals in detail the size and shape of the building units which provide the rigid framework for greases.

In Fig. 1 are shown the microcrystals or fibers of several alkali metal soaps from greases. Lithium soaps form either short, rod-like fibers (about 1 *mu* or 1/25000 inch long) or longer rope-like fibers (10-20 *mu* long) depending upon the fatty acid used to make the soap. Similarly, sodium soaps form short rods as well as very long fibers, depending upon fatty acid composition and manufacturing conditions.

Fig. 1 Fiber structure of alkali metal soap greases (X8000 except as marked). Key (from left to right): lithium soap (short), lithium soap (medium), sodium soap (short), sodium soap (long)

The polyvalent metal soap particles of Fig. 2 show similar variety in size and shape.

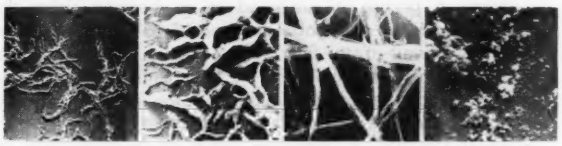


Fig. 2 Fiber structure of polyvalent metal soap greases (X8000). Key (from left to right): calcium soap, strontium soap, barium soap, aluminum soap

Some of the newer types of thickening agents are shown in Fig. 3. These are materials which are insoluble in oil even at very high temperatures, but which can be dispersed by milling to form greases. The individual particles of carbon black and fumed silica are roughly spherical, and they are aggregated into groups of irregular shape. The alkylammonium bentonite (clay derivative) particles are fine irregular flakes.

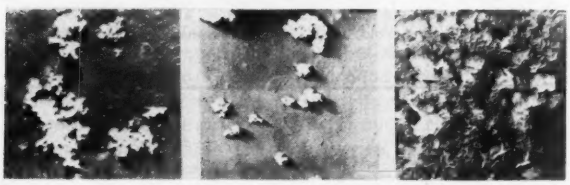


Fig. 3 Fiber structure of nonsaponaceous thickeners from greases (X8000). Key (from left to right): carbon black, fumed silica, alkylammonium bentonite

In general, greases containing the smaller thickener particles are smooth textured and clear or translucent. Such greases find application for the lubrication of high-speed ball bearings as in electric motors, and automotive chassis. Greases containing the long thread-like thickener particles are stringy or fibrous and usually less clear optically. They find application in automotive wheel bearings and larger bearings and gears where the fibrous structure contributes to good retention and proper feeding onto the surfaces being lubricated.

Fine, rod-like or thread-like particles give stiffer greases than do globular or thick rod-like particles.

STRUCTURAL CHANGES WITH TEMPERATURE

The fine structure shown in the electron micrographs is present at ordinary temperatures. At higher temperatures, structural or phase changes occur in soap-thickened greases. These changes may lead to failure of the part being lubricated. A knowledge of the changes which occur in various greases is therefore valuable for selection of a grease to be used for particular temperature conditions.

The following most noticeable phase-temperature relations exist in typical soap-thickened greases: (1) Temperature below 200 F., Grease Phase: Microcrystalline paste; (2) Temperature between 200 and 400 F., Grease Phase: Gel; (3) Above the gel temperature, Grease Phase: Solution. Lawrence[8] and Vold and Vold[10] have determined and interpreted phase changes which occur in several soap-oil systems.

A simple, practical method of determining phase changes is as follows: Samples of grease (100 g.) are weighed into Buchner funnels, heated to the desired temperature, and filtered through analytical filter paper with the aid of suction for two hours. The filtrates are weighed and filtrate weights plotted against filtration temperatures to produce a phase-temperature diagram.

Phase-temperature diagrams obtained in this manner for various greases are shown in Fig. 4. As the temperature rises from 100 to 300 F., the lithium soap grease is seen to be a paste with increasing oil separability. At 300-350 F. oil separability decreases as a result of gelation. No soap is present in the filtrate below 350 F. Above 350 F. the soap dissolves and both soap and oil are in the filtrate. The sodium soap grease forms a gel and subsequently a solution at lower temperatures than the lithium soap grease. The aluminum soap grease goes through these structural changes at still lower temperatures.

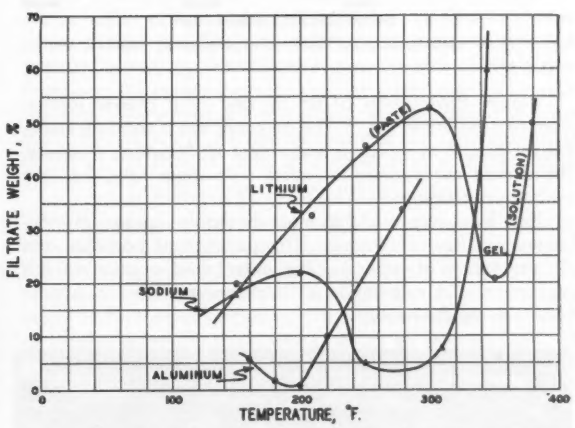


Fig. 4 Effect of cation variation on filtrability of stearate soap greases

As a practical application of these curves one would predict that the lithium soap grease, for example, would lubricate satisfactorily below 250 F., but it would exhibit considerable oil leakage in a bearing at 250-300 F.; it would probably channel and feed poorly at 350 F. because of its rubbery nature at this temperature, and it would rapidly leak out of the bearing above 350 F.

DYNAMIC STRUCTURE

The network of thickener particles present in a grease is strong enough to prevent it from flowing under the influence of weak forces such as that of gravity on small samples. But the network is too fragile to resist moderatly large shearing forces, and greases flow with increasing ease as the shearing force is increased. Some mathematical equations which have been used to define and describe flow of greases follow (P — pressure, r — radius, l — length, v — velocity, Q — quantity per unit time, n — viscosity, and k, a, b, and c are constants): FLOW EQUATIONS: (1) Shear stress: $S = Ppi\ r^2/2pi\ rl$ dynes/cm^2; (2) Shear rate: $D = dv/dr$ or $4Q/pir^3$ sec^{-1}; (3) Newton $D = 1/n\ S$; (4) Bingham: $D = 1/n\ (S\text{-}S_o)$; (5) Goodeve: $n = n_o + k\ l/D$; (6) Ryan-Christiansen: $aD + \ln D = b + c\ S$. Newton's relation between shear stress and

shear rate applies strictly only to true fluids although it is used for calculation of apparent viscosity of greases at varying shear rates. The succeeding three equations have been proposed to relate shear rate and shear stress for plastic materials and they may be used to describe portions of grease flow curves but the complete flow curve of a grease from zero to very high shear rates is apparently very difficult to define with a single equation.

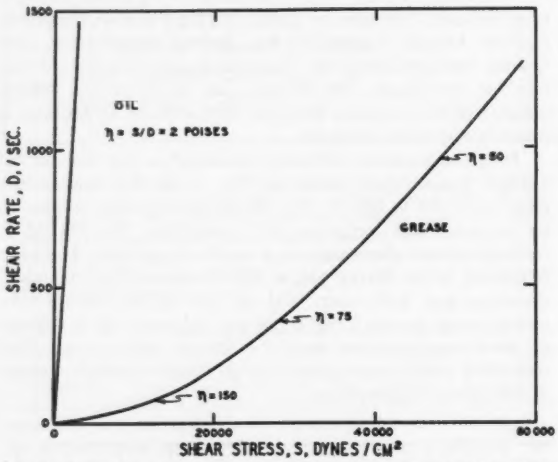


Fig. 5 Shear rate—shear stress relationship of base oil and 14% sodium soap grease

Typical flow curves of an oil and of a grease formed from that oil are in Fig. 5. The oil curve has a constant slope, the reciprocal of which is equivalent to Newton's viscosity. The grease curve slope increases with shear rate, (i.e., the viscosity decreases).

The following are the most probable causes of non-Newtonian flow of greases: (1) separation of particles, and (2) orientation of particles. The extent and position of this separation and orientation of thickener particles in a tube vary with the flow rate.

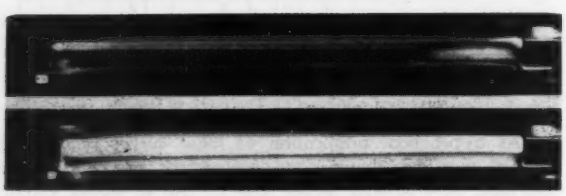


Fig. 6 Lithium soap grease between crossed polaroids. Key: Top—still, bottom—moving 30 CM/SEC

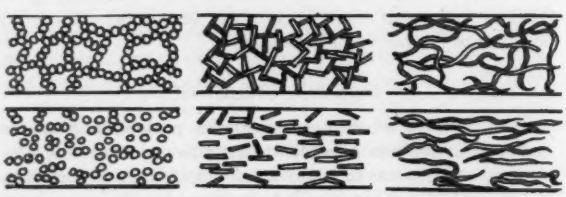


Fig. 7 Grease flow mechanism. Key: Top—still, bottom—flowing.

The latter of these two phenomena may be demonstrated experimentally by observation of still and flowing grease between crossed polarizing screens. The large increase in light transmission which occurs upon flow under these conditions (Fig 6) is proof that the rod-like lithium soap particles in this grease assume parallel alignment during flow. Gray and Alexander[6] and Gallay, Puddington and Tapp[5] have previously investigated this phenomenon for other soap dispersions.

The probable behavior of typical thickener particles on flow is shown in Fig. 7. Orientation is most evident among rod-shaped thickener particles.

Flow properties of greases are important in determining the ease with which they can be pumped into parts requiring lubrication as well as in determining the amount of torque required to rotate bearings containing the greases.

CONCLUSIONS

The semisolid character of lubricating greases depends upon a supporting framework of thickener particles.

The size and shape of the thickener particles determine the consistency and texture of greases and in turn their most appropriate application.

Radical structural changes occur in soap-thickened greases with increasing temperature and they must be considered during the selection of a grease for use in equipment operating at a particular temperature.

When a grease is subjected to a shearing stress the thickener particles disengage and line up to varying degrees and thus permit it to flow like a liquid. Such structural changes during flow determine the ease with which a grease can be pumped through a pipe and the amount of drag exerted by the grease in a rotating bearing.

REFERENCES

[1]Birdsall, D. H., and Farrington, B. B.: J. Phys. and Colloid. Chem., 52, 1415-23, 1948.

[2]Boner, C. J.: The Manufacture of Lubricating Greases. Petroleum Refiner, 28, March-July, 1949.

[3]Browning, G. V.: Inst. Spokesman (National Lubricating Grease Inst.) 14, No. 1, 10-15, 1950.

[4]Farrington, B. B.: Ann. N. Y. Acad. Sci 53, Art. 4, 979-86, 1951.

[5]Gallay, Puddington, and Tapp.: Can. J. Research 22B, 70, 1944.

[6]Gray, V. R., and Alexander, A. E.: J. Phys. and Colloid. Chem., 53, 9-22, 1949.

[7]Klemgard, E. N.: Lubricating Greases: Their Manufacture and Use. Reinhold, 1937.

[8]Lawrence, A. S. C.: J. Inst. Petroleum 31, 303-14, 1945.

[9]Vold, Hattiangdi, and Vold.: Ind. Eng. Chem. 41, 2539-46, 1949.

[10]Vold, M. J., and Vold, R. D.: Inst. Spokesman (National Lubricating Grease Inst.) 13, No. 5, 10-14, 1949.

POSITION OPEN
for
SALES ENGINEER

To sell and service oiling and filtering systems, fuel and lubricating oil filters and oiling devices used on large engines, pumps, and machinery. Two or three years experience. Graduate Mechanical Engineer, about 30 years old. Good health, good habits. Must have a car to call upon the Chicago territory, as well as travel throughout the United States. Not a "high pressure artist." Must have a gentleman's apparance and behavior to represent old, established small firm with dignity. Aspire to increase sales and earn higher salary. Salary commensurate with past earnings and ability. Write Box LE-1.

LUBRICATION ENGINEERING
343 S. Dearborn Street
Chicago 4, Illinois

DISPENSING CHARACTERISTICS OF LUBRICATING GREASES*

by R. F. Strohecker
AiResearch Mfg. Co.
9851 Sepulveda Blvd.
Los Angeles 45, Calif.

Mr. Strohecker received a B.S. degree in Mechanical Engineering from Renselaer Polytechnical Institute in 1944. Upon graduating, he was employed by The Texas Co. After a short period he was granted leave of absence for service with the U. S. Navy, after which he received a M.S. degree from Northwestern University in 1947 and returned to the Beacon Laboratories of The Texas Co. He is presently employed as a Development Engineer with the AiResearch Mfg. Co.

ABSTRACT: The primary object of this work was the development of relative dispensing data on commercial greases having different soap bases and mineral oil contents, with the secondary object being to relate the foregoing data to a laboratory testing device to facilitate the determination of the relative pumpability characteristics of greases.

The paper describes the work done in testing thirty greases, over a temperature range, in air-operated service-station-type pumps to determine the dispensing characteristics of the greases. The relationship of the laboratory restrictions used to actual vehicle shackles and fittings is presented, with the development of suitable failing conditions to interpret the test data. The various factors affecting pumpability are also discussed.

The development of a method relating failing temperatures determined from actual pumping tests to failing temperatures as determined from ASTM Pressure Viscosimeter data is presented, and shown to be satisfactory with a high degree of accuracy.

INTRODUCTION

The complete development of lubricants, designed to do a given job, should include a knowledge of their dispensing characteristics. A program was initiated at the Beacon Laboratories of The Texas Co. to determine the pumpability characteristics of numerous greases. The type of unit chosen for this work was the air-operated type of pump, equipped with a seven-foot grease hose and control valve, designed to operate from a 100-pound grease cartridge. This type of pump is found in service station and industrial applications.

Test data obtained, over a temperature range, on various greases were examined for the possibilities of relating actual pumping data to some laboratory-testing device. The satisfactory correlation obtained with the pressure viscosimeter resulted in a simple method for the examination of the dispensing characteristics of greases.

AIR-OPERATED TEST EQUIPMENT

The specific equipment used in conducting this test work consisted of two different model pumps of the air-operated, high pressure service station type fitted with seven feet of hose, 1/4 in. I.D., and a control valve. These guns are designed to pump from 100-pound cartridges.

The two types of pumps were comparable, with the exception of the grease pressure/air pressure ratio. These ratios were 50/1 and 40/1. The significance of this ratio is as follows: for every pound of air pressure supplied, the pump will develop a grease pressure corresponding to its respective grease pressure/air pressure ratio.

The grease gun, as illustrated in Fig. 1 is composed of two integral parts, an air motor and the grease-pumping mechanism contained in the suction stub which is actuated by the air motor. The gun fits on the top of a 100-pound grease cartridge with the suction stub immersed in the grease.

The reciprocating action of the air motor, caused by the reversal of the air supply to both sides of the piston, is transmitted to the high pressure piston by the connecting shaft. An extension of this shaft carries the reciprocating action further to the primer.

The grease flows into the suction stub through ports and on an up-stroke of the gun is picked up by the primer, which forces the grease up through the foot valve into a chamber below the high-pressure piston.

On a successive down-stroke of the gun, the high-pressure piston comes down on the grease above the foot valve and forces it past the check valve (shown as a ball in the high pressure piston), up into the high pressure side of the pump. From here the grease flows through the pump and out through the hose. The pumps are essentially constant-volume devices since the delivery of the grease depends upon the displacing action of the constant bore and stroke high-pressure piston.

LABORATORY FLOW RESTRICTIONS

When absolute free-flow conditions are used to measure the relative rating of ease of pumpability of several greases, there is the possibility of misleading answers being obtained because of the magnitude of the quantity of grease delivered. Notwithstanding this fact, it was considered necessary to include some condition which would be representative of optimum flow conditions. Therefore, nominal free-flow data were obtained which consisted of pumping through a 1/8-inch hydraulic fitting complete with check valve. The hydraulic fitting is the means by which the control valve of the grease pump is coupled to the lubrication points in service.

The shackle (given as part of equipment for use with CRC Test Procedure L-29-545 "Low Temperature Pumpability") shown in Fig. 2 (consisting of a sleeve fitted with a tapered pin) was used as a means to simulate service conditions and also to obtain high resistance to the flow of the lubricant.

COLD ROOM SETUP

The compact, self-contained nature of the air-operated pumps did not necessitate an elaborate setup of this equipment within the cold room. The various pumps were set in place on the 100-pound cartridges of the respective test greases, and connected to the air supply.

The air supply consisted of a separate air compressor, typical of those found in service stations, mounted outside of the cold room. The compressed air was piped from the compressor through an air dryer, consisting of trays containing calcium chloride within a 6 in. vertical pipe, to a reducing valve which maintained the air pressure at 125 p.s.i. (measured on the surge tank). From the reducing valve, the air line then passed to a 30-gallon surge tank mounted directly outside of the cold room. From the surge tank a 1-inch pipe led through the cold room wall. The flexible rubber air hose to the pumps was connected to the end of this pipe within the cold room.

* Sponsored by the Technical Committee on Lubrication Equipment and presented at the 7th Annual Meeting, ASLE, Cleveland, April 8, 1952

This flexible hose was removed from the cold room after each day to prevent any detrimental effect of the lower temperatures on the hose material.

The condition of the air hose also may lead to insufficient delivery of grease. The interior may be rough and since most air hoses are made from rubber and have an outer and inner liner, it is possible for a pin point defect in the inner lining of the hose to occur. This small hole with the hose, under pressure permits air pressure to act on the outside of the inner liner forcing it into the I.D. of the hose causing a restriction. This restriction could easily result in an insufficient amount of air supply to the pump and consequently a reduction in the delivery of grease.

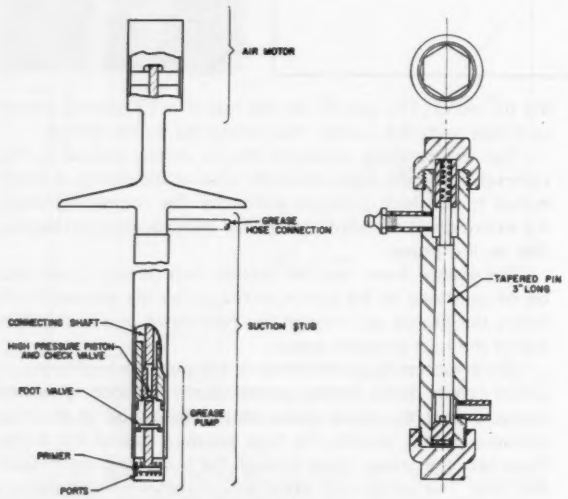


Fig. 1 (left) Air-operated grease pump
Fig. 2 (right) Shackle—effective radius 0.204 CM

Following the assembly of the pumps and grease cartridges containing 35 to 40 pounds of grease in the cold room, a soaking period of approximately 24 hours with the grease at the test temperature was initiated as it was found that approximately 17 hours were required for the center of the grease in a 100-pound cartridge to assume a lowered test temperature.

After the soaking period, the actual tests were performed. Employing 125 p.s.i. air supply pressure to the pump, the grease was pumped first through the restricted shackle condition and then through the nominal free-flow condition (the 1/8-inch hydraulic fitting). To obtain the maximum amount of information, the length of time and amount of grease delivered for a number of complete cycles of the pump (the test procedure utilized was not identical to that proposed by the NLGI co-operative work on pumpability but embodied the same principles as given in the proposed standard method. *Institute Spokesman*, May, 1951) were measured. Three determinations under each flow condition were made at each test temperature.

The temperature of the cold room was progressively lowered until the amount delivered per minute under the free-flow condition approximated 10 grams. For several of the greases it was found necessary to utilize a follower plate in order to continue pumping.

The data obtained with the foregoing test procedure are considered representative of the pumpability characteristics of the various greases. In certain cases the follower plate was used to insure that the feeding of the grease to the pump was positive and that the data obtained were truly representative pumping data not influenced by feeding characteristics to the pump suction intake.

The failure of the grease to slump to the intake ports of the pump is known as air-binding.

GREASES EVALUATED

The general characteristics of the thirty greases evaluated are shown in Table I. These greases were chosen to include the major variations of soap and oil components found in commercially available products.

THE ESTABLISHMENT OF FAILING CRITERIA TEST SHACKLES VERSUS AUTOMOTIVE FITTINGS

Before definitely establishing the failing criteria in terms of delivery rates in grams per minute, a limited amount of work was performed in order to correlate the relationship between the flow conditions utilized in this test work with those encountered in automotive lubrication.

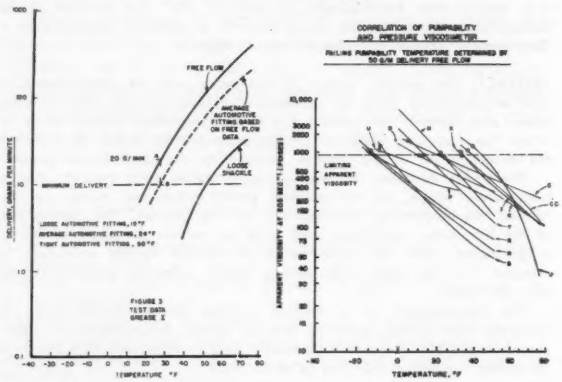


Fig. 3 (left) Test data, Grease I
Fig. 4 (right) Correlation of pumpability and pressure viscosimeter. Failing pumpability temperature determined by 50 G/M delivery free flow

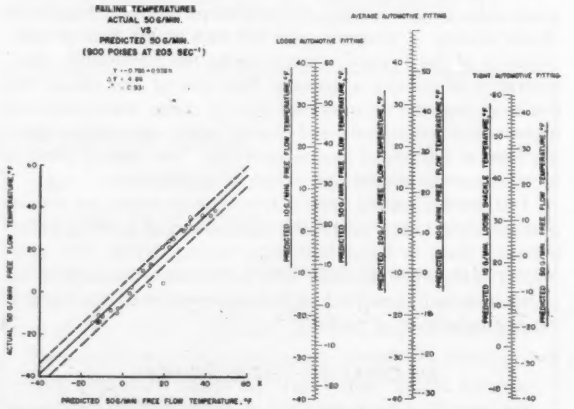

FAILING TEMPERATURES ACTUAL 50 G/MIN. VS PREDICTED 50 G/MIN. (900 POISES AT 205 SEC⁻¹)
PREDICTED 50G/MIN FREE FLOW TEMPERATURE, °F
ACTUAL 50 G/MIN FREE FLOW TEMPERATURE, °F
AVERAGE AUTOMOTIVE FITTING
LOOSE AUTOMOTIVE FITTING
TIGHT AUTOMOTIVE FITTING

Fig. 5 (left) Failing temperatures, actual 50 g./min. vs. predicted 50 g./min. (900 poises at 205 Sec. $^{-1}$).
Fig. 6 (right) Predicted 50 g./min. free flow temperature vs other failing criteria

The work necessary to establish the relationship between the automotive fittings and the test shackles was accomplished at room ambient temperature by using Grease J as the lubricant and actually lubricating four automobiles which were considered representative of those encountered in service station operations. The cars were as follows: a 1950 Cadillac, 1949 Buick, 1950 Plymouth which had been in use and had received lubrication at 1000-mile periods, and a 1947 Ford which had not been in use nor lubricated for a period of approximately one year. The 1947 Ford was utilized in order to include a severe condition.

The test procedure utilized in this phase of the work consisted of measuring the length of time to lubricate each fitting with one full stroke of the pump. A full stroke of the pump was used as it would have been virtually impossible to collect and weigh the amount of grease delivered to each fitting on the various vehicles with normal service station operation. From the test work conducted in the cold room, it was determined that the pump used in these tests had an approximate delivery of 14 grams per stroke. Utilizing the measured time per stroke and the figure of 14 grams for one stroke, the delivery rates through the restriction offered by the automotive fittings were determined. These data are summarized in Table II with the average delivery for the various points of lubrication given for the vehicles lubricated.

TABLE I
GREASES EVALUATED

Grease	Soap Base	% Soap	Viscosity Mineral Oil SUS 100 F.	Viscosity Mineral Oil SUS 210 F.	Dropping Point F.	Worked Pen.
A	Ca	9	300	48	204	380
B	Ca	12	314	48	215	337
C	Ca	13	356	49	215	280
D	Ca	17	322	47	208	234
E	Ca	9	2248	89	214	314
F	Ca	12	2254	89	222	280
G	Na	17	318	48	341	235
H	Na	3	3040	139	134	324
I	Na	6	3523	196	363	367
J	Na	6	4213	179	331	334
K	Na	11	1294	88	416	278
L	Na	18	1509	93	420	242
M	Na-Pb	16	3665	121	332	324
N	Na-Ca	11	295	52	311	360
O	Na-Ca	17	320	51	311	267
P	Na-Ca	17	177	45	297	278
Q	Ca	7	340	54	307	355
R	Ca	9	335	54	211	334
S	Ca	13	425	63	205	282
T	Na-Ca	22	216	47	352	338
U	Na-Ca	21	203	47	363	...
V	Na-Ca	25	315	53	349	308
W	Ca + Graphite	17	700	74	207	320
X	Ca + Graphite	16	2488	105	204	305
Y	Al	8	554	54	200	335
Z	Al	12	1339	83	206	284
AA	Li	18	51	33	353	288
BB	Li	20	74	38	359	280
CC	Ca	11	3517	1446	200	325
DD	Ca	6	3210	145	Semi-Fluid	265

As was mentioned, the delivery rates through the shackle and for free flow were also obtained using the same test setup. These delivery rates are also indicated on Table II.

It is readily apparent from Table II that the shackle represents a more severe condition than is encountered in an actual automotive fitting; for instance, 142 grams per minute was determined to be the overall average delivery rate for all the vehicles, with an average of 9.1 grams per minute being obtained through the shackle. However, it was found that the free-flow conditions which, as had been pointed out, were made through a 1/8-inch hydraulic fitting complete with check valve, were within the range of some of the fittings encountered in the vehicles, particularly the tie rods. Considering the minimum delivery rate (for two points on the 1947 Ford, there was not one stroke in five minutes; therefore, because of excessive time, data were not taken. These, of course, represent an extremely low delivery rate and are, therefore, not truly representative.) of 2.6 grams per minute found with the automotive fittings through one of the control arm points of the 1950 Plymouth and the maximum delivery of 300 grams per minute found in one of the tie rod points in the 1949 Buick, it is apparent that the shackle was representative of the most adverse conditions found in an actual vehicle and the free-flow condition is representative of the most unobstructed condition found with an actual automotive fitting.

In view of the foregoing, it appears that the failing criteria established purely on the basis of (1) the free-flow condition (which represents flow through a 1/8-inch fitting) and (2) the data obtained with flow through the shackle, will serve to rate greases in terms of service behavior.

CHOICE OF FAILING CRITERIA

From the foregoing sections it is apparent that the flow conditions from which the failing criteria should be established are free-flow conditions (considered in this work to be a flow through 1/8-inch hydraulic fitting) and flow through the shackle. With these typical restrictions, however, it is still necessary to establish a time interval and a given delivery in this interval in order to form a basis for a failing delivery rate from which the relative ratings of the pumpability characteristics of the various products tested may be compared.

TABLE II
AVERAGE DELIVERY OBTAINED IN LUBRICATION OF AUTOMOBILES[1] VERSUS DELIVERY THROUGH LABORATORY RESTRICTIONS

	Average Delivery through Laboratory Restrictions (Check Runs)					
	Control Arms	King Pins	Tie Rods	Pedal Shafts	Shackle	Free Flow (1/8 inch hydraulic fitting)
	Delivery g./min.					
1950 Cadillac	166.9[a]	107.4	262.0	122.1	7.6	281.0
1950 Plymouth	49.9[b]	105.6	258.8	78.6	9.8	304.0
1949 Buick	177.1	187.4	272.5	60.9	8.3	298.5
1947 Ford	[c]	105.1	142.5	43.3	10.8	....
Average	131.3	126.6	233.9	76.2	9.1	294.5

Average of all fittings—142.7
[1]60 p.s.i. Air Pressure, Temperature 73 F.
[a]Includes maximum delivery of 300 g./min.
[b]Includes minimum delivery of 2.6 g./min.
[c]No control arm points.

The arrival at a given delivery rate was made in the following manner: since the flow conditions utilized in the pumpability work had been correlated with automotive fittings, it was felt that the delivery rate upon which the relative ratings of the various products are obtained should also be made from automotive work. Therefore, a survey of five service stations was made and revealed that four to five vehicles can be lubricated with a total consumption of one pound of grease. Next, an assumption was made, namely that there are approximately 25 grease fittings per car. From the foregoing, the amount of grease per fitting was calculated to be 4.5 grams. Then, assuming that an operator would allow at least 30 seconds at each fitting, the round number of 10 grams per minute was arrived at as the minimum delivery rate.

From the work conducted in establishing the relationship between the automotive fittings and the flow conditions, it was found that the average overall delivery rate for the fittings on all the cars was 142.7 grams per minute. It was also determined that, under the same conditions of ambient temperature and air pressure supply to the gun, the delivery rate under the free flow conditions (1/8-inch hydraulic fitting) was 294.5 grams per minute. Utilizing these two delivery rates, a ratio may be formed between the delivery rate under the free-flow condition and the anticipated average delivery rate found in a vehicle. This results in a ratio of 2 to 1.

Therefore, considering Fig. 3 which represents the pumping data obtained in the cold room for Grease I, it can be

seen that it is possible to develop a curve from the cold room data which appears representative of the average automotive fitting. Also from this curve, it should be possible to obtain a definite failing temperature based on the 10-gram-per-minute delivery rate which would be considered an average for automotive work.

TABLE III
FAILING TEMPERATURES[1] F.

	Failing Criterion			
Grease	10 g./min. Free Flow[2]	20 g./min. Free Flow[3]	10 g./min. Loose Shackle[4]	50 g./min. Free Flow
A	—34	—25	24.5	—11.5
B	—35.5	—26	27.5	— 9
C	—19	—10	38	2
D	—11	— 3	42.5	10
E	18	24	48.5	32
F	14	20	47	30
G	—12	— 5.5	17.5	4
H	4.5	10.5	44	21
I	19	24	49	31.5
J	22	28	53.5	38
K	7	14.5	38	24
L	20	25.5	52.5	36
M	2.5	10	39.5	21
N	—29.5	—24.5	5.5	—15
O	—21.5	—14	31	— 0.5
P	—26.5	—22	7.5	—11.5
Q	—26.5	—21.5	34.5	13
R	—29.5	—23	3	—14.5
S	—19.5	—16	12	— 8
T	—29	—23	2.5	—14.5
U	—28	—21	3	—10
V	— 9.5	— 4	23	3
W	2	6.5	34.5	13
X	12	19.5	54	29.5
Y	— 4	2.5	31.5	12
Z	—20	26	52	35
AA	[a]	[a]	—19	—41
BB	[a]	[a]	[a]	[a]
CC	20	26.5	59	35.5
DD	8	14	43.5	24.5

[1]Average of failing temperatures obtained in Pumps—125 p.s.i. air supply pressure.
[2]Loose automotive fitting.
[3]Average automotive fittings.
[4]Tight automotive fitting.
[a]Temperature below cold room minimum.

From the foregoing three definite failing criteria have been established on the basis of the delivery rate of 10 grams per minute. These are as follows:

LOOSE AUTOMOTIVE FITTING: The failing criterion which is representative of the maximum delivery in an actual vehicle may be obtained from the free-flow data.

AVERAGE AUTOMOTIVE FITTING: The failing criterion which is representative of an average of various automotive fittings may be obtained from the free-flow data with a delivery of 20 grams per minute (equivalent to 10 grams/minute delivery rate on the curve developed for the average automotive fitting).

TIGHT AUTOMOTIVE FITTING: The failing criterion of the most adverse flow condition found in an automotive fitting is represented by flow through the shackle.

PUMPABILITY RATINGS TEST RESULTS

It has been pointed out previously that the test results obtained in the work reported herein are considered to be on the basis of pumpability alone, as when there were indications of air binding, a follower plate was used. Also, from the preceding sections different criteria to be used to rate the various greases have been developed. As pointed out, these criteria, though considered valuable, contain certain assumptions and are based on limited field data. Therefore, a direct relative rating of pumpability should be made, when desired, by comparing the greases directly on the basis of their test results.

A typical example of the test data obtained is found in Fig. 3. The various failing points are shown labeled with the failing temperatures for the different failing conditions.

RELATIVE RATINGS OF PUMPABILITY RESULTS

The actual failing temperatures of the greases tested in the two types of pumps, basis the established failing criteria, are found in Table III. The temperatures shown are an average of the failing temperatures obtained in both the pumps.

TABLE IV
COMPARISON OF PREDICTED AND ACTUAL FAILING TEMPERATURES

Grease	Predicted[1] Failing Temperatures °F.	Actual Failing Temperatures[2] °F.
A	—10	—11.5
B	— 6	— 9
C	4	2
D	9	10
E	31	32
F	30	30
G	19	4
H	22	21
I	23	31.5
J	44	38
K	22	24
L	42	36
M	19	21
N	—13	—15
O	3	— 0.5
P	—12	—11.5
Q	—13	—14.5
R	— 3	—10
S	13	3
T	—15	—15
U	—12	—14.5
V	— 3	— 8
W	13	13
X	29	29.5
Y	13	12
Z	32	35
AA	—30	—41[a]
BB	—48	[a]
CC	24	24.5
DD	38	35.5

[1]Based on apparent viscosity at 205 sec. $^{-1}$ and maximum apparent viscosity of 900 poiseS.
[2]Average of failing temperatures for both Alemite and Graco Units, 50 g./minute Free Flow.
[a]Below range of cold room ambient test temperatures.

It was found that the difference in the grease pressure/air pressure ratio did not affect the actual failing temperatures by an appreciable amount.

COMPARISON OF FIELD AND LABORATORY RESULTS

The following information concerning the satisfactory pumpable temperatures of Chassis Lubricants was obtained

TABLE V
EQUATIONS OF LINES RELATING ACTUAL AND PREDICTED TEMPERATURES

Actual 10 g./min. Free Flow Temperature (Y)
Predicted 50 g./min. Free Flow Temperature (X)
$Y = -17.424 + 0.9579X$
$\Delta Y = 6.09$
$r^2 = 0.958$

versus

Actual 20 g./min. Free Flow Temperature (Y)
Predicted 50 g./min. Free Flow Temperature (X)
$Y = -10.005 + 0.9571X$
$\Delta Y = 5.37$
$r^2 = 0.922$

versus

Actual 10 g./min. Loose Shackle Temperature (Y)
Predicted 50 g./min. Free Flow Temperature (X)
$Y = 21.45 + 0.847X$
$\Delta Y = 8.29$
$r^2 = 0.796$

as a result of a survey of service stations located throughout the country. The following information is based on comments given by certain dealers and sales representatives: Grease H —There were indications from five dealers that this grease

(Continued on page 263)

Lubrication Summarized

CENTRALIZED LUBRICATION

by M. B. Lawton, Lincoln Eng. Co., ASLE Saginaw Valley Section Meeting

The practice of industrial lubrication must recognize these underlying fundamentals: (1) A lubricant is inert of purpose until in the presence of a bearing; (2) Lubrication pre-supposes a proper lubricant film permanently maintained; (3) The permanence of a lubricant film depends upon the frequency with which replenishing lubricant is applied; (4) Lubrication, therefore, is a product of two factors: lubricant and lubricant application; (5) A lubricant film can be maintained only if lubricant application is controlled; (6) The control of lubricant application is tantamount to the control of bearing wear; (7) Successful bearing performance is more responsive to frequency of lubricant application than to type of lubricant; (8) The method of lubricant application predetermines the lubricant consistency; (9) The selection of a lubricant for any purpose whatsoever cannot be made intelligently without knowledge of the method of application; (10) The peak of industrial production can be attained only to the extent that industrial lubrication is understood and achieved.

Petroleum companies have spent millions of dollars in research developing lubricants to meet tremendously advanced machine requirements—and yet, according to the editors of Fortune magazine, 90% of industry is still relying on the oil can and the grease gun in the hands of an oiler to protect and maintain its production machinery—an investment of billions of dollars.

Finest lubricants in the world—finest machines ever developed, and the oil can and grease gun are depended upon to apply one to the other. Is it any wonder that industry accepts fabulously expensive down-time due to improper lubrication, and the replacement of prematurely worn bearings as customary operating routine.

The inadequacy of the oil can and grease gun to meet today's machine lubrication requirements rests in the fact that this method provides no elements of control.

One can only assume: (1) the right lubricant has been selected in the instance of every bearing; (2) every bearing will be located and contacted; (3) the proper amount of lubricant will be applied to each bearing; (4) lubricant will be applied at the proper time intervals; (5) as applied, lubricant will flow to the bearing; (6) the lubricant will be free of contamination.

Aside from lacking the required elements of control, the cost of the oil can and grease gun is threefold: (1) the initial cost; (2) the cost of carrying them around; (3) the cost of the consequences resulting from the way they are used.

Now, in contrast to individual contact methods, let us consider the degree of "control" provided by modern centralized lubrication systems.

Stated in simplest terms, the centralized system comprises a lubricant pump and a series of measuring valves or injectors with provision for cycling all valves in an entire system, simultaneously, at predetermined time intervals to insure the application of a measured amount of lubricant to each bearing under positive pressure.

From the foregoing brief description it at once becomes obvious how centralized systems, alone, can provide the greatest degree of control over application. For example: (1) The right lubricant, as pertains to all bearings served by a centralized system, is determined from the data acquired by testing different lubricants as to performance characteristics while exposed to actual conditions under which the lubricant is required to perform; (2) A bearing lubricant film can be maintained constantly by the control possible in timing the frequency of lubricant replenishment; (3) Each bearing is certain to receive the intended lubricant in the predetermined quantity and at the specified time interval by means of the selective setting of the pressure developed by the central pump, sufficient to positively force lubricant to the bearing; (4) Contamination of lubricant is controlled when dispensing from an original refinery container through the sealed injector circuit direct to the bearing.

Acknowledging the fact that centralized lubrication systems provide all the elements of control required for the maintenance of a constant flow of clean lubricant on bearing surfaces, let us see how this effects operating costs.

In contrast with the three-fold cost of the individual contact method, the centralized system involves just one cost. The initial cost is the total cost. But the outstanding contrast is the fact that the centralized system refunds its total cost in lowered operating expense in all major catagories, over and over again. as long as it is used, while individual contact methods continue to increase in cost, indefinitely.

This is readily explained, because it: (1) prevents waste of lubricant; (2) reduces man-hours devoted to lubricant application to a very minimum; (3) eliminates machine down-time for lubrication; (4) eliminates machine down-time for repairs due to bearing failure or faulty operation of worn parts resulting from inadequate lubrication; (5) increases productive rate and efficiency of machinery to a uniform maximum; (6) improves quality of product; (7) eliminates product spoilage from dripping of excessive lubricant; (8) reduces power requirements by eliminating friction—maintains power used consistent with work done; (9) eliminates personal injuries and corresponding compensation costs attributable to lubricant application.

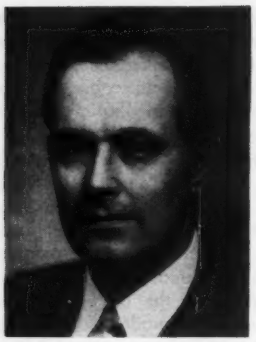
The fullest advantage to be derived from centralized systems cannot be achieved by merely selecting and installing a system on a given machine. Centralized mass lubrication is the answer, that is, to blanket the total requirements of existing machine units, and allow for future additions much the same as the planning of an installation for power, gas or water. Therefore a detailed survey of machine lubrication requirements is necessary in order to select a system that is sufficiently flexible in application and uniform in design to meet all conditions. Where possible, machines should be grouped in banks or zones of 25 to 50 machine units, and served by one central time clock controlled pump.

Recent trade paper articles provide forceful testimony of multiple savings which accrue from centralized systems. For example—a tire manufacturer equipped plant machinery with centralized mass lubrication at a cost of $35,000, and showed that down-time for hand lubrication would have equalled the output of more than $250,000 worth of production a year; a steel mill claims a clear saving of $104,904 annually on bearings alone, plus a 40% reduction in power consumption on tilting tables; a fire brick manufacturer installed centralized lubrication on 26 presses and saved a minimum of $45,500 annually on repairs; a textile mill equipped 86 machines with centralized systems and reports an average saving of $1,726 per machine, annually; a coal company saved $75,000 a year on their stripping shovels and $32,240 in labor cost alone in their preparation plant.

When a lubrication engineer has at his disposal the means to control lubrican application and hence operating costs, he can then rise above a level reliant upon the recommendations of lubricant compounders and the frustration of machinery builders, immune from the hazards of inadequate maintenance routines and practices, let alone the unpredictable consequences

(Continued on page 267)

A. Bondi


J. Boyd

W. E. Campbell

D. D. Fuller

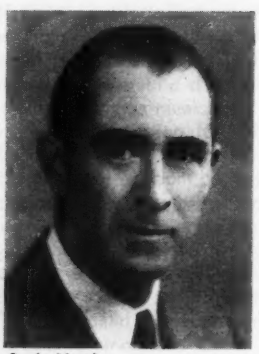
E. K. Gatcombe

SYMPOSIUM HI-LITES

Papers presented at the First National Symposium on the Fundamentals of Friction and Lubrication in Engineering held at the Hotel Sherman, Chicago, September 8 & 9, 1952, included: Remarks on Mixed Film Lubrication, by A. Bondi; Presentation of Lubrication Concepts for Engineering Application, by J. Boyd; The Modern Theory of Solid Friction in Contact Resistance Studies, by W. E. Campbell; Historical Development of Modern Lubrication Concepts, by D. D. Fuller; On the Need for a Non-Steady State Theory for Lubrication Hydrodynamics, by E. K. Gatcombe; Fundamentals of Hydrodynamic Lubrication, by M. D. Hersey; Physics and Chemistry of Rubbing Solids—Basic Principles, by R. G. Larsen; Vertical Pivoted-Shoe Thrust Bearings, by S. J. Needs; Lubrication of Gear Teeth Including the Effect of Elastic Displacements, by H. Poritsky; The Interaction of Wear Fragments, by E. Rabinowicz; Friction and Wear of Graphite and Other Layer-Latticed Solids, by R. H. Savage; Practical Application of Rubbing Surface Concepts, by M. C. Shaw. A publication of these papers will be made available, the time and price to be announced later.

M. D. Hersey

R. G. Larsen


S. J. Needs

H. Poritsky

E. Rabinowicz

R. H. Savage

M. C. Shaw

Lubrication in the News

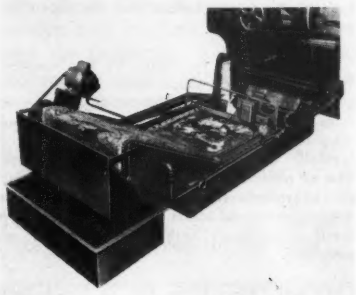
AEROLUBE 92, a new additive for lubricating oil which will permit efficient use of fuels with high sulfur content under severest operating conditions, combines oil antioxidant and bearing corrosion inhibition properties with highly effective alkaline detergency. Specifically designed for use in Series 2 oils which are recommended where high sulfur fuels are used in high output supercharged equipment which is to be operated with or without high sulfur fuels, Aerolube 92 is recommended at a concentration of 11.75%, by volume, to meet the rigorous requirements of the Series 2 type lubricants. Oils compounded with this additive at this concentration also meet existing standards of silver bearing compatibility. For further information write American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y.

AUTOMATIC HI PRESSURE BOOSTER GUN has been designed for the following applications: (1) Lubrication of bearings on industrial machinery requiring injection of a small quantity of lubricant at extremely high pressure; (2) An auxiliary high pressure lubricator to service bearings requiring injection of limited quantities of special purpose lubricants; (3) Cracking "frozen" or clogged bearings on Contractors' equipment without use of power-operated gun. For complete details write for Bulletin No. 681, Lincoln Engineering Co., 5743 Natural Bridge Ave., St. Louis, Mo.

BETTER ANALYSIS, Vol. 3, No. 2, describing interesting application of infrared analysis at Interchemical Corp., Wyandotte Chemical Corp., and The Andrew Jergens Co., and presenting details of the diesel oil maintenance program at American Locomotive Co., and a thorough treatment of furnace control analysis at Kaiser Steel Co., is available upon request from Baird Associates, Inc., 33 University Road, Cambridge 38, Mass.

COLLOIDAL GRAPHITE FOR SURFACE COATINGS AND IMPREGNATION, Bulletin No. 435, has been released by The Acheson Colloids Co., manufacturer of "dag" colloidal graphite dispersions, and a division of Acheson Industries, Inc. Bulletin No. 435 may be obtained by writing to Acheson Colloids Co., Port Huron, Mich.

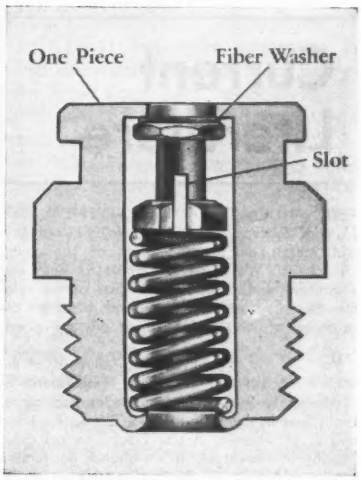
CYANAMID METALLIC STEARATES, a booklet which describes revised specifications of many grades resulting from recent research by the company in the stearate field and includes controls on the purity and uniformity of the component fatty acids and extremely low limits of lead and arsenic, may be had by writing American Cyanamid Co., Industrial Chemicals Div., 30 Rockefeller Plaza, New York, N. Y.



DELPARK INDUSTRIAL ENDLESS BELT FILTER, designed to service individual machine tools or larger central coolant systems, is a continuous, self-cleaning gravity filter which filters solids from liquids that flow by gravity through filter material and discharges the solids, in a relatively dry state, into an outside container. Sloping sides form a shallow pool of the conveyor and an inclined discharge ramp provides for the removal of filtered solids. For further information write The Industrial Filtration Co., Lebanon, Ind.

DOW CORNING SILICONE NOTEBOOK, Reference No. 2003, covering Dow Corning 200 Fluids, presents over twenty different properties, from boiling point to sound transmission, thoroughly discussed and illustrated, with references, a blending chart for intermediate viscosities, and numerous pictures and descriptions of current industrial applications. Copies are available upon request from Dow Corning Corp., Midland, Mich.

ELECTRIC CLOSED CUP FLASH TESTER for flash and fire point determination of volatile, flammable liquids flashing below 175, F., in accordance with ASTM Method D-56, has been developed that gives greater accuracy of temperature control, achieved by the "Handi-Hot Plate" heater, wide heater temperature range (from 100 to 700 F.), and greater safety since the only open flame present is that used to create the flash. Precisely made of stainless steel and brass, the hot plate and support collar are steel with a heat- and corrosion-resistant baked enamel finish. For further information write Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.



GIANT BUTTONHEAD GREASE FITTING with one-piece construction imparting stronger, longer-wearing, abuse-resisting qualities for use on all heavy industrial machinery, provides maximum grease flow and prevents the leaking possible with conventional two-piece buttonhead fittings which can be separated by extreme pressure or jolting. This product also features a strong steel inner-spring which combines with a fiber sealing washer to prevent grease leak-back. Write for free 1952 Universal Industrial Catalog, Universal Lubricating Systems, Inc., 690 Allegheny Ave,. Oakmont, Pa.

GULF NO-RUST FPR, a new compound capable of removing damaging fingerprints and other similar corrosive materials from fine finished surfaces and establishing a corrosion preventive film sufficiant to protect the part between manufacturing operations and during temporary storage, has been developed by the Gulf Oil Corp. Containing a highly effective and potent rust preventive, it may be applied to steel, brass, copper, cadmium, magnesium, zinc, and other metal surfaces by dipping, flooding, or spraying. For further information write Gulf Oil Corp., 722 Gulf Building, Pittsburgh, 30, Pa.

LOK-TITE REUSABLE COUPLINGS, a line of new couplings, can be used over and over again wherever there are flexible hose lines. Positive grip eliminates dependence on pressure from wedging the core in the sleeve to holding coupling to hose; bell-shaped counter bore of sleeve eliminates difficulty in starting hose into couplings and engages flared ends acting as a screw; extra large flow-passage in stud, plus shorter overall length of stud reduces restriction to a minimum; end of core is completely confined by metal, assuring safer handling, positive leak-

(Continued on page 267)

Current Literature

AERONAUTICAL ENGINEERING REVIEW, Vol. 11, No. 6, June, 1952, Catalytic Effect of Several Metals on the Oxidation of Lubricating Oils, by D. W. Sawyer. Quantitative data and equipment and procedure for tests of the relative effects of various metals and alloys on the oxidation of mineral lubricating oils are given.

Vol. 11, No. 7, July, 1952, Influence of Lubricant Viscosity on Operating Temperatures of 75-Mlillimeter-Bore Cylindrical-Roller Bearing at High Speeds, by E. F. Macks, W. I. Anderson and Z. N. Nemeth. A size 215 cylindrical roller bearing in current use in an aircraft gas-turbine engine was used as the test bearing in an investigation of the effects of oil viscosity, oil flow, and oil inlet temperature on the operating characteristics of high-speed roller bearings.

AMERICAN PAINT JOURNAL, Vol. 36, No. 45, July 28,1952, Characteristics of Aluminum Soap Gels, by M. L. Stumpf. Of the seven aluminum soaps discussed in these studies, aluminum octoate proves to be far superior in producing a stable, high-yield gel in a variety of solvents. One of the many applications of the aluminum salt of ethylhexoic acid is a varnish drier. The octoate is stable, hydro-carbon, soluble, high in metallic content, light in color and is practically odorless compared to the naphthenic acid driers now used. Gels produced with aluminum stearate, laurate, myristate, and palmitate do not remain stable after aging for a period of time. With gels of mineral spirits, the net result will be an unstable gel which develops syneresis and haze. If mineral spirits is to be used as a solvent, aluminum octoate or oleate should be used, depending on the gel strength required. Detailed reports of physical constants of the aluminum gels in various solvents are given in tables.

ANALYTICAL CHEMISTRY, Vol. 24, No. 5, May, 1952, Tapered-Hole Disk Penetrometer for Determining Consistency of Semifluid Greases, by D. H. Birdsall and B. W. Hotten. Table I summarizes present methods for determining semifluid grease consistency, showing method, apparatus, advantages and disadvantages. A modified Potter McLennan perforated disk, having tapered holes, was devised and used in connection with the ASTM penetrometer. Consistencies of 9 semifluid greases were determined with this apparatus, and results are compared with other methods.

CHEMICAL ABSTRACTS, Vol. 46, No. 11, June 10, 1952, Polyvan Rust-Inhibitors, by J. Stepanek. A general description is given of the mode of action, properties, and rust-inhibiting uses of polymerized organovanadium, organotitanium, and alkali platinum cyanides.

A Rapid Method of Estimation of Triethanolamine In Lubricating Oils, by S. Das Gupta, K. K. Ganguli, S. K. Chaterjee and A. P. Chakravarty. The formation of a stable water-soluble salt with mineral acids is used in the determination of triethanolomine. After addition of excess hydrochloric acids and alkalizing with sodium hydroxide, titration of excess alkali with methyl orange was employed.

Vol. 46, No. 12, June 25, 1952, Friction of Clean Metals and the Influence of absorbed Films, by F. P. Bowden and J. E. Young. An experimental study of the frictional behavior of degassed metal surfaces was made. Various gases and vapors were absorbed on the clean specimens, and their influences on friction determined. The specific contaminants are most effective as lubricants where they can react with the metal to form a solid and chemically attached film which is several molecular layers thick. Otherwise the friction remains very high, although seizure is prevented. Physical absorption may occur in addition, with a significant reduction in the friction. The results support the view that the friction of metals is due mainly to adhesion at the points of real contact, and is governed by the extent to which even the thinnest of surface films can reduce this metallic contact.

Detergents From Petroleum, by G. Trinchieri. The syntheses of: soaps from synthetic fatty acids (obtained by oxidation of paraffin or from olefins and carbon monoxide), alkyl sulfates from olefins by direct sulfonation of from synthetic alcohols, alkylsulfonates by sulfonation of paraffins, alkylaryl-sulfonates by sulfonation of synthetic alkyl benzenes and naphthalenes alkylarylpolyglycol ethers by condensation of synthetic alkylphenols with ethylene ovide, are described.

CHEMICAL PROCESSING, Vol. 15. No. 6, June, 1952, Quartet of Castor Oil Derivatives For Use In Synthetic Waxes, Lubricants, Greases, Anon. Paricin 1 (methyl hydroxy stereate) is suggested by Baker Castor Oil Co., New York, for application in manufacture of multi-purpose greases and synthetic waxes, Solricin 2 (ammonium ricinoleate, 85% solution) in manufacture of rust-preventive compounds, and calcium and magnesium ricinoleates in lubricants.

CHEMICAL WEEK, Vol. 71, No. 1, July 5, 1952, New Grease Beats The Heat, Anon. V. G. Fitzsimmons, R. L. Merker, and C. R. Singleterry of Naval Research Laboratory, Washington, D. C., have developed a new lubricating grease formulation, with copper phthalocyanine as the gelling agent, that performs satisfactorily over the minus 80 F. to plus 400 F. temperature range. It's a silicone grease. Estimated price of the grease is about $5 a pound.

FUEL ABSTRACTS, Vol. 11, No. 5, May, 1952,- Effect of Chemical Reactivity of Lubricant Additives on Friction and Surface Welding at High Sliding Velocities, by E. E. Bisson, M. A. Swikert, and R. L. Johnson. The additives used, benzyl chloride, dichlorobenzene free sulfur, benzyl disulphide, and phenyl monosulphide were mixed with cetane. Results showed that greater chemical reactivity of the active atoms from various additives gave a high critical sliding velocity, and indicated the importance of rate of reaction between extreme pressure lubricant additives and sliding surfaces.

INSTITUTE OF PETROLEUM REVIEW, Vol. 6, No. 66, June, 1952, Modern Techniques in Petroleum Testing and Mechanical Tests for Lubricants, by H. L. Bingham. Mechanical tests for gear oils, cutting fluids, aviation gas turbine oils, and hydraulic fluids are discussed. For the measurement of load-carrying capacities the SAE, Timken, Four Ball, Falex and Almen machines are used, as well as IAE ¾-inch gear machine. Use of these machines is described and typical results in gear oil testing are compared.

INSTITUTE SPOKESMAN, Vol. 16, No. 3, June, 1952, Fretting Corrosion Studies With a Modified Fafnir Machine, by T. G. Roehmer and E. L. Armstrong. Fretting corrosion, or friction oxidation, is the removal of very finely divided metal from bearing surfaces due to inherent adhesive forces which are assisted by vibratory motion. Mechanical factors which were studied included arc of oscillation, frequency of oscillation and applied load. The lubricating grease variables investigated were primarily consistency and additives, including extreme pressure gear oil type additives containing sulfur and chlorine. Effects of graphite or molybdenum disulfide dispersions were also considered. Conclusions are as follows: 1. The tendency toward fretting corrosion is promoted by increasing the arc and frequency of oscillation of the bearings. 2. Before differences in quality of lubricating greases can be realized they must have the proper consistency to "track" properly, i.e., to permit renewal of lubricating film.

JOURNAL OF APPLIED CHEMISTRY, Vol 2, Part 5, May, 1952, The Influence of Soap-Phase Structure on Some Physical Properties of Lithium Greases, by D. Evans, J. F. Hutton, and J. B. Matthews. A colorimeter and technique used for measuring the temperature and the latent heats of phase transformation in greases are described. Greases examined were made from lithium stereate, lithium 12-hydroxystereate, or mixtures of these two soaps and a hydrocarbon lubricating oil made by solvent refining of a naphthenic crude oil. Estimates of the solubilities of the soaps in the oil as functions of temperature have been made on the basis of the latent-heat data. The hardness and the resistance to oil separation are found to be determined by the soap phase existing during the growth of the fibres.

LUBRICATION (Texas Co.), Vol. 38, No. 7, July, 1952, Some Recent Concepts of Machinability, Anon. Great strides have already been made in establishing some of the basic principles and underlying laws that govern the cutting and machining of metals. Although the story of metal cutting is far from being complete and much additional basic work still remains to be done, fundamental information is being accumulated at such a rapid rate that it appears the time is not far off when all of the variables that influence the operation will be identified and their inter-relationships established. By the proper use of a suitable fluid substantial increases in tool life and improvements in surface finish can be realized. Most of these cutting fluids are supplied by the petroleum industry, and represent years of continued research and development.

MECHANICAL ENGINEERING, Vol. 74, No. 7, July, 1952, Better Lubricants, Anon. Brief descriptions of the following 3 Navy research reports recently made available by the office of Technical Services, U. S. Department of Commerce, are given: PB 103,774, "Surface Chemical Phenomena In Lubrication," PB 103,606, "A Study of the Four-Ball Wear Machine," PB 106,130, "Synthesis and Characteristics of Esters and Ethers for Nonspreading Lubricants."

OIL ENGINE AND GAS TURBINE, Vol. 20, Mid June, 1952, Crankcase Explosions, Anon. For an explosion to occur it is necessary to have potentially dangerous air-oil conditions within the crankcase, and the availability of a hot spot or other ignition source and the critical time. The author states that casual treatment of the process of change-over from straight mineral lubricating oil to a heavy-duty additive type can give rise to lubricating failure, and the risk of a crankcase explosion.

Vol. 20, Mid July, 1952, Lubricant Investigation Provides Defects Warning, Anon. The article discusses how spectographic analysis of used oil ash indicates bad mechanical condition, either impending or in existence.

PETROLEUM, Vol. 15, No. 6, June, 1952, Viscometer Difficulties, Anon. Viscosities taken with a British Ford cup viscometer were found recently to cary up to 100% with results taken using an American Ford viscometer. A British Standards (number not given) for measuring viscosity of certain products (not specified) gives specifications for the Ford cup viscometer, whereas there

(Continued on page 268)

Book Reviews

DECHEMA MONOGRAPHS, VOLUME 20

by Dechema, Publishers, Deutsche Gesellschaft fur chemisches Apparatewesen, Frankfort am Main 13, Postfach, Germany, 1952, 500 pages, 225 illustrations, price $37.50.

DECHEMA MONOGRAPHS, VOLUME 20, is a series of twenty-three lectures by lecturers from ten different countries delivered at the recent European Convention of Chemical Engineering in conjunction with the XXV Congress International de Chimie Industrielle and the Achema X, dealing with the following main themes: Basic Chemical Engineering, Automatic Measuring and Control Devices in the Laboratory and Works, Continuous Chemical Processes, The Realization of Extreme Conditions in Chemical Engineering, and Materials and Corrosion.

FOURTH EDITION TRUCK LUBRICATION GUIDE

by Chek-Chart Corp., Publishers, 31 E. Congress St., Chicago 5, Ill., 1952, 96 pages, price $15.00.

FOURTH EDITION TRUCK LUBRICATION GUIDE, carrying manufacturer-approved lubrication recommendations for all light and heavy trucks produced by nineteen truck manufacturers in the ten years including some of the more popular older trucks to give the most comprehensive coverage of truck lubrication recommendations available, is designed to help service station men everywhere provide proper lubrication for more than 85 per cent of trucks currently on the road. Within the reference are 84 truck lubrication diagrams, 10 pages of popular axle unit diagrams, composite charts of trailer and semi-trailer components, six pages of general lubrication instructions and also a page of diagrams and instructions covering lubrication of truck cab points. For larger trucks having many optional combinations of engine, transmission and differential, recommendations have been compiled in tabular form, making it easy to find different combinations without hunting through a number of cross-references.

PROPERTIES OF THE PRINCIPAL FATS, FATTY OILS, WAXES, FATTY ACIDS AND THEIR SALTS

by M. P. Doss. The Texas Co., Publishers, Technical and Research Div., 135 E. 42nd St., New York 17, N. Y., 1952, 244 pages, 1,350 literature references, price $5.00.

PROPERTIES OF THE PRINCIPAL FATS, FATTY OILS, WAXES, FATTY ACIDS AND THEIR SALTS, an authoritative survey which covers its field in exhaustive detail, should be of considerable interest to the fatty oil, petroleum, and chemical industries, and especially to manufacturers of lubricants. The publication covers the properties of approximately 50 of the principal fats, fatty oils, and waxes; though the author surveys only aliphatic acids, he tabulates the properties of more than 800 of these. A unique part of the book is the data given on the salts of the fatty acids ranging from aluminum through zirconium. Approximately 1,750 salts are listed. The book concludes with a variety of pertinent conversion tables (i.e., temperature, gravity, viscosity, color) and a detailed subject index.

Personals

STEWART-WARNER CORP. has purchased substantial stock interest in and will have operating control of Uni-Gun Lubricating Equipment, Ltd., of London, England, for the purpose of furthering the distribution of ALEMITE and Uni-Gun products not only in Great Britain but in the world markets . . . L. L. ROBB, former assistant to the president of Stewart-Warner Corp., has been named to head sales to car factories and other original equipment users of Alemite lubrication equipment and Stewart-Warner instruments . . . The Chicago office address of the American Society of Mechanical Engineers, publishers of MECHANICAL ENGINEERING and ASME Mechanical Catalog and Directory, has been changed to 84 E. Randolph St., Chicago 1, Ill. . . . Sinclair Research Laboratories, Inc, announces the promotion of Dr. K. A. SMITH to the post of Director of the Light Oils Div., M. R. FAIRLIE to the post of Director of Lubricants Research, W. R. RIGGS to the position of Manager in Charge of General Services, and R. H. GARDNER to the newly created position of Research Associate . . . Captain R. D. PHILLIPS, Sherwood Brothers Inc., former commanding officer of the U S. Naval Reserve Brigade in Baltimore and a sectional sustaining member of the ASLE Baltimore Section, died July 17, 1952 . . . COMMERCIAL FILTERS CORP., manufacturers of FULFLO Filters for the microscopic clarification of industrial liquids and gases, has moved from Boston to its new factory at 2 Main St., Melrose 76, Mass. . . . Correction: A. E. CICHELLI has been promoted to Chief Lubrication Engineer of the Bethlehem Steel Corp, with headquarters at Bethlehem, Pa. . . . The AP Parts Corp. has announced the appointment of O. A. (Lee) ROEGER to Assistant to the Sales Manager and the promotion of T. HARVEY to Manager of Territory No. 2. . . . J. L. PARKER has been appointed Advertising and Merchandising Manager of the Graton & Knight Co, manufacturer of industrial leather, and will direct sales promotion activities for G & K affiliates: International Packings Corp., manufacturer of synthetic rubber packings; Dixie Leather Corp., manufacturer of textile leather. . . . R. M. Hollingshead Corp, Camden, N. J., world's largest manufacturers of maintenance chemicals, has appointed T. H. RISK, formerly a research engineer for the Ethyl Corp., a new Vice-President of the corporation, and P. JONES, former administrative assistant to Montgomery Ward & Company's retail vice-president, to the position of Assistant Director of Sales and Merchandising. . . . E. R. BAKER has been promoted to manager of Continental Oil Company's Development & Research Dept., with headquarters in Ponca City, succeeding L. L. DAVIS, who is retiring after 25 years of service but will continue to serve the company in a consulting capacity. . . . Shell Chemical Corp. announces the appointments of D. H. BRADLEY to Manager of its Detroit district sales office, succeeding W. E. KEEGAN who has been appointed to the position of Assistant to the Vice-President, Marketing; J. M. SELDEN to Manager of the Eastern Div., and L. LYKKEN to Manager and M. M. ROSSON to Assistant Manager of the Technical Service Dept. of its recently purchased Denver firm of Julius Hyman & Co. . . . A W. PAYNE'S retirement as Chairman of the Board of Directors of Crane Packing Co., after more than 30 years active participation, has been announced, with F. E. PAYNE, formerly President of the company, elected Chairman of the Board, and K. V. ROHLEN succeeding to the Presidency from his former position of Vice-President and General Manager. . . . Y. KOWABARA, an operating engineer of a rolling mill in the Tin Plate Dept. of the Toyokohan Co., Ltd., Kudamatu Yamaguchi, Japan, visited the ASLE National Office re maintenance problems. . . . Gulf Oil Corp. announces the appointments of C. W. HEALY to Div. General Manager of the Philadelphia Sales Div., succeeding R. E. GARRETT who has retired after 41 years of service, D. R. FERRIS to Div. General Manager of the Boston Sales Div. R. P. HUGGINS to a Vice-President of Gulf

Oil Corp. and Gulf Refining Co., with T. H. WALLACE appointed Vice-President in charge of Western Gulf Oil Co., the division of the Chemistry Div. of Gulf Research & Development Co. at Harmarville, Pa., into a Product Div. with Dr. H. A. AMBROSE, appointed Director and a Process Div. with Dr. C. W. MONTGOMERY named Director and W. C. OFFUTT serving as Assistant Director. . . . (NOTE: Submit copy for any LE feature to Editorial Assistant, LUBRICATION ENGINEERING, 343 S. Dearborn St., Chicago 4, Ill.)

Coming Events

OCTOBER

13-15—American Petroleum Credit Assn., LaSalle Hotel, Chicago, Ill.

13-15—Texas Mid-Continent Oil & Gas Assn. (33rd Annual Meeting), Hotel Texas, Fort Worth, Texas.

13-17—American Institute of Electrical Engineers (Fall General Meeting), Jung Hotel, New Orleans, La.

15-17—Canadian Inst. of Mining & Metallurgy (Annual Western Meeting), Royal Alexandra Hotel, Winnipeg, Man., Canada.

19—Natural Gasoline Assn. of America (Southern Regional Meeting), The Blackstone Hotel, Tyler, Texas.

20-21—Independent Petroleum Assn. of America (Annual Meeting), Mayo Hotel, Tulsa, Okla.

20-21—Independent Petroleum Assn. of America (Annual Meeting), Mayo Hotel, Tulsa, Okla.

20-22—American Oil Chemists' Socy. (Fall Meeting), Netherland Plaza Hotel, Cincinnati, Ohio.

20-24—National Safety Council (40th National Safety Congress & Exposition), Conrad Hilton Hotel, Chicago, Ill.

22-24—Socy. of Automotive Engineers (National Transportation Meeting), Hotel William Penn, Pittsburgh, Pa.

23-24—American Inst. of Mining and Metallurgical Engineers (Petroleum Branch—West Coast Fall Meeting), Statler Hotel, Los Angeles, Calif.

27 Wk.—American Gas Assn. (Annual Convention), Auditorium, Atlantic City, N. J.

28-30—American Inst. of Electrical Engineers (District No. 2 Meeting), Commodore Perry Hotel, Toledo, Ohio.

29—Oil Trades Assn. of New York, Inc., Waldorf-Astoria Hotel, New York, N. Y.

30—American Socy. for Testing Materials (St. Louis District Meeting), St. Louis Mo.

30-31—Socy. of Automotive Engineers (National Diesel Engine Meeting), Chase Hotel, St. Louis, Mo.

30 to Nov. 1—Rocky Mountain Oil & Gas Assn. (Annual Meeting), Cosmopolitan Hotel, Denver, Colo.

NOVEMBER

4-5—Nebraska Petroleum Marketeers, Inc. (Annual Convention), Hotel Paxton, Omaha, Neb.

6-7—Socy. of Automotive Engineers (National Fuels & Lubricants Meeting), Mayo Hotel, Tulsa, Okla.

8-13—Oil Industry Information Committee, Conrad Hilton Hotel, Chicago, Ill.

10-13—American Petroleum Institute (32nd Annual Meeting), Conrad Hilton and Palmer House Hotels, Chicago, Ill.

13—American Petroleum Institute (Executive Committee Meeting), Conrad Hilton Hotel, Chicago, Ill.

17 Wk.—American Socy. for Testing Materials (Southern Calif. District), Los Angeles, Calif.

19—American Standards Association (34th Annual Meeting), Waldorf-Astoria Hotel, New York, N. Y.

20-21—American Socy. for Quality Control (7th Midwest Conference), Indianapolis, Ind.

25—American Socy. for Testing Materials (Northern Calif. District), San Francisco, Calif.

30 to Dec. 5—American Socy. of Mechanical Engineers (Annual Meeting), Statler Hotel, New York, N. Y.

DECEMBER

1-6—20th National Exposition of Power & Mechanical Engineering, Grand Central Palace, New York, N. Y.

7-10—American Inst. of Chemical Engineers (Annual Meeting), Hotels Cleveland and Carter, Cleveland, Ohio.

APRIL, 1953

13-15—American Socy. of Lubrication Engineers (8th Annual Meeting, 6th Annual Exhibit), Hotel Statler, Boston, Mass.

New Members

AMBLER, G. C., Navy Dept., Bu. Ships, Washington, D. C.

BAXLEY, G. B., Crompton & Knowles Loom Works, Charlotte, N. C.

BENDER, A. J., Pure Oil Co., Akron, Ohio

BROCK, R. C., North American Rayon Corp., Elizabethtown, Tenn.

BROOKS, R. R., Cities Service Oil Co., St. Paul Minn.

BROWN, G. E., Alemite Co., Cincinnati, Ohio

BURGESS, P. B., Standard Oil Co. (Ind.), Chicago, Ill.

BURKE, T. E., Cities Service Oil Co., Chicago, Ill.

CAROLAN, W. C., Farval Corp., Kansas City, Mo.

CLARKE, W. W., Cities Service Oil Co., Kansas City, Mo.

COERPER, P. R., Cities Service Oil Co., Appleton, Wis.

ELSLEY, C. H., Dominion Foundries & Steel Ltd., Hamilton, Ontario, Canada

FENG, I-Ming, M.I.T., Cambridge, Mass.

FLEMING, B. E., Cities Service Oil Co., Milwaukee, Wis.

GILMORE, C. D., Mueller Brass Co., Port Huron, Mich.

GREEN, E. G., Allison Div. of GMC, Indianapolis, Ind.

HARDWICK, T. A., Sherrill Oil Co., Pensacola, Fla.

HEIST, F. L., E. F. Houghton & Co., Philadelphia, Pa.

HERMAN, T. A., Worthington Corp., Harrison, N. J.

HOFMAN, E., Esso S. A. Petrolera Argentina, Argentina, S. A.

HOLODNIK, E., Gulf Research & Development, Pittsburgh, Pa.

HYLAND, M. T., Cities Service Oil Co., Milwaukee, Wis.

KEEFER, M. A., Jr., Bowser, Inc., San Francisco, Calif.

KEENAN, M. J., Standard Oil Co. (Ind.), Cheyenne, Wyo.

LACOURT, R., Esso Standard, Antwerp, Belgium.

LAWRENCE, J. R., American Cast Iron Pipe Co., Birmingham, Ala.

LITZSINGER, H. S., Monsanto Chem. Co., St. Louis, Mo.

MacAULEY, J. D., Bowser, Inc., San Francisco, Calif.

McGURN, C. E., Bridgeport-Lycoming (AVCO), Stratford, Conn.

MERCER, C. S., Morgan Construction Co., Worcester, Mass.

OLSON, C. K., Standard Oil Co., Minneapolis, Minn.

PATTIE, F., Cities Service Oil Co., Chicago, Ill.

PETERSEN, R. W., Northland Products Co., Waterloo, Iowa

PFEIFFER, W. H., Ternstedt Div. GHM, Columbus, Ohio

PONTIOUS, R. L., Sinclair Research Laboratories, Harvey, Ill.

PRENDERGAST, R. E., Continental Can Co., Chicago, Ill.

RAY, L. O., Aluminum Co. of America, Cleveland, Ohio

RODEWALD, W. H., Cities Service Oil Co., Milwaukee, Wis.

RYDER, E. A., Pratt & Whitney Aircraft, E. Hartford, Conn.

SANDERS, C. J., Jr., Lion Oil Co., Nashville, Tenn.

SAUTER, N. A., Deere & Co., Moline, Ill.

SCHLEICHER, B. T., Black Bear Co., Inc., Long Island City, N. Y.

SIMS, H. E., Esso Standard Oil Co., Syracuse, N. Y.

SPARKS, J. G., Cities Service Oil Co., Chicago, Ill.

TOBUREN, W. D., Cities Service Oil Co., Kansas City, Mo.

TOMPACH, S. J., Cities Service Oil Co., Milwaukee, Wis.

TRAVIS, J. A., I.B.M. Corp., Poughkeepsie, N. Y.

VIDOSIC, J. P., Georgia Institute of Technology, Atlanta, Ga.

WARD, W. W., Pure Oil Co., Wheeling, W. Va.

WILSON, C. E., Union Oil Co. of Calif., Brea, Calif.

Patent Abstracts

Prepared by ANN BURCHICK from Official Gazette—Vol. 659, No. 4; Vol. 660, Nos. 1, 2, 3, 4, 5; Vol. 661, Nos. 1, 2, 3. Printed copies of patents are available from the Patent Office at twenty-five cents each. Address the Commissioner of Patents, Washington, D. C., for copies and for general information concerning patents.

OIL SOLUBLE FURFURAL-PHENOL RESINS, Patent #2,601,498, L. H. Brown, assignor to The Quaker Oats Co. The method for producing an oil soluble resin which comprises heating a mixture consisting of furfural and phenol in the approximate ratio of 1 to 4 in the presence of a basic catalyst until a viscous liquid is obtained, adding acid thereto until said mixture is slightly acid and then removing the excess phenol and water therefrom.

CLAY DECOLORIZING OF SOLVENT REFINED LUBRICATING OILS, Patent #2,602,044, G. L. Lupfer, R. G. Atkinson, and J. D. Stubbs, assignors to The Standard Oil Co. A process for refining a mineral oil stock which comprises adding furfural to said mineral oil stock, separating the extract, adding a decolorizing clay to the mixture of refined oil stock and furfural, heating the resultant slurry of refined oil stock, furfural and clay to a temperature to distill off the furfural and improve the color of the oil stock, adding methyl-ethyl-ketone to the slurry of refined oil stock and clay, chilling the slurry to precipitate wax from the oil, separating said clay and the precipi-

tated wax from said oil and said methyl-ethyl-ketone, and subsequently separating said methyl-ethyl-ketone to produce a refined, dewaxed and decolorized oil.

LUBRICATING OIL ADDITIVES, Patent #2,602,-048, A. E. Michaels and N. V. Hakala, assignors to Standard Oil Development Co. A non-turbid lubricating oil blend having a high viscosity and exhibiting a high degree of detergency which consists essentially of a mineral oil base stock having combined therein about 0.05% to about 10% by weight of a copolymer of a maleate ester containing from 10 to 16 carbon atoms in the ester portion thereof and vinyl acetate, from about 0.2% to 3.0% by weight of a detergent inhibitor selected from the class consisting of metal salts of alkylated phenol sulfides and reaction products of metal salts of alkylated phenol sulfide, and a phosphorus sulfide, and from about 0.01% to 1.0% by weight of a compatibility improver of the class consisting of diethylene glycol monethyl ether, methoxy triglycol, and dimethoxy tetraethylene glycol.

TETRATHIOETHERS OF PENTAERYTHRITOL, Patent #2,602,050, R. T. Sanderson, assignor to The Texas Co. An improved mineral oil composition comprising a mineral oil fraction of lubricating properties and 0.5 to 25 per cent tetraalkylthioether of pentaerythritol.

PREVENTION OF FOAMING OILS, Patent #2,-603,599, C. E. Trautman, assignor to Gulf Research & Development Co. An oil composition comprising a stable fine dispersion in an oil of an antifoam composition consisting essentially of a polyhydric alcohol having a surface tension greater than the surface tension of the oil and selected from the class consisting of glycols and glycerols and a surface active agent, having the property of lowering the surface tension of said polyhydric alcohol, in an amount sufficient to lower the surface tension of the polyhydric alcohol to a surface tension equal to or less than the surface tension of the oil, said dispersion containing said polyhydric alcohol and said surface active agent in a proportion of 1 to 100 parts by weight of polyhydric alcohol per part by weight of surface active agent, the combined weight of said polyhydric alcohol and said surface active agent being sufficient to decrease the normal foaming tendency of the oil.

ADDITION AGENTS AND MINERAL OIL LUBRICANT COMPOSITIONS CONTAINING THE SAME, Patent, #2,603,600, H. G. Smith and T. L. Cantrell, assignors to Gulf Oil Corp. The process of preparing an improvement agent for mineral oil lubricants which comprises heating an essentially paraffinic base lubricating oil with anhydrous aluminum chloride at a temperature of from 150 to 300 F., removing aluminum-chloride from the reaction product, and reacting said product and from 5 to 50 per cent by weight of an monohydric alkylated phenol having at least 4 carbon atoms in an alkyl group with phosphorus pentasulfide at an elevated temperature not below 300 F. and not in excess of the minimum cracking temperature of said product to incorporate phosphorus and sulfur therein.

LUBRICATING COMPOSITIONS, Patent, #2,603,-604, S. A. Ballard, R. C. Morris, and J. L. Van Winkle, assignors to Shell Development Co. A stable liquid lubricating composition comprising 90-99% by weight of a liquid aliphatic ester of a bis (hydroxyalkl) sulfide, the hydrocarbon units of said ester being aliphatic hydrocarbon radicals having from 2 to 20 carbon atoms each, and 1-10% by weight of a polymerized methacrylic acid ester having a molecular weight between 10,000 and 25,000.

LUBRICATING OIL ADDITIVE MATERIALS PREPARED BY CONDENSING ALKYL HALIDES WITH HALOAROMATIC-ALIPHATIC HYDROCARBON COPOLYMERS, Patent #2,603,627, J. D. Garber and D. W. Young, assignors to Standard Oil Development Co. A process for the preparation of lubricating oil additives which comprises condensing with a halogenated aliphatic hyrdocabon containing from 5 to 30 carbon atoms a copolymer of parachloro styrene and isobutylene in the presence of a Friedel-Crafts catalyst, said copolymer containing from about 1.0% to 30% by weight of para-chloro styrene having a molecular weight of more than 14,000 and having been copolymerized at a temperature below about —50 C. in the presence of a Friedel-Crafts catalyst.

CATALYTIC REACTION OF ISOBUTANE AND PROPYLENE TO PRODUCE LUBRICATING OIL, Patent #2,603,666, R. J. Fritz, assignor to Standard Oil Development Co. A method of preparing a synthetic hydrocarbon lubricating oil which comprises continuously passing a mixture of 4 to 6 molecular proportions of isobutane and 1 molecular proportion of propylene through a reactor in contact with an aluminum chloride catalyst and simultaneously and continuously recycling a portion of the total normally liquid reaction product to said reactor, the volume ratio of recycled product, exclusive of any unreacted isobutane, to the fresh feed mixture entering the reactor being 4-6/1, while maintaining in the reactor a temperature of 60-90 F. and a pressure sufficient to maintain a liquid phase reaction, and maintaining such a rate of flow through the reactor that the contact time is 5 to 15 minutes.

METHOD OF REDUCING THE VISCOSITY AND GEL STRENGTH OF OIL BASE DRILLING FLUID, Patent #2,604,448, D. L. Wilson, assignor to Oil Base, Inc. A drilling fluid having a suspending medium consisting solely of a mineral oil, said fluid including a compound selected from the group consisting of terpenes, terpene alcohols, terpene ketones and terpene ethers, the amount of such compound being between 0.05% and 10% by weight of the remaining ingredients.

TWISTER RING LUBRICANT, Patent #2,604,452, A. J. Morway and D. W. Young, assignors to Standard Oil Development Co. A new and improved twister ring lubricant consisting essentially of a white petrolatum containing dispersed therein from 1% to 10% by weight, based on the weight of the total composition, of an N-acyl p-amino phenol, the acyl group of which contains from 12 to 22 carbon atoms.

NEW COPOLYMER COMPOSITIONS, Patent #2,-604,453, A. H. Popkin, assignor to Standard Oil Development Co. A composition consisting essentially of a mineral oil base stock and from 0.1% to 15% by weight based on total composition of a copolymer of 80% to 95% lauryl acrylate and 20% to 5% methyl acrylate, said copolymer having an average side chain length in the range of 7.5 to 10.6 carbon atoms, said composition having a viscosity index substantially greater than that of said mineral oil.

METALWORKING LUBRICANT, Patent #2,605,-224, E. L. Jahn, assignor to Shell Development Co. A metal working lubricant comprisign a sulfide acid-treated light liquid hydrocarbon having a boiling range of from 300 F. to about 700 F. having incorporated therein from 3 to 10% of a fatty material selected from the class consisting of lanolin, oleyl alcohol and olein.

STABILIZED GREASES, Patent #2,605,225, E. L. Armstrong and R. A. Butcosk, assignors to Socony-Vacuum Oil Co., Inc. A grease comprising predominantly a lubricating fraction of mineral oil, a minor proportion of a thickening agent and an amount of a carboxylic acid type ion-exchange resin effective to stabilize said grease to oxidation.

COMPOUNDED LUBRICATING OIL, Patent #2,-605,226, S. C. Vaughn, assignor to Tide Water Associated Oil Co. A hydrocarbon lubricating oil containing a rust-inhibiting quantity of the addition product of an amino bicyclohexyl and alkyl acid phosphate having from 8 to 16 carbon atoms per alkyl group.

SILICONE GREASES, Patent #2,606,153, N. C. Holdstock, assignor to General Electric Co. A grease composition consisting essentially of a major proportion of a liquid organopolysiloxane base fluid and a minor proportion of a thickening agent consisting of lithium 2-ethylhexoate, the organic groups in the aforesaid organopolysiloxane being selected from the class consisting of methyl and phenyl groups and the latter organic groups being present in the ratio of from 1.95 to 2.25 organic groups per silicon atom.

LUBRICATING OIL ADDITIVE, Patent #2,606,182, J. M. Musselman, assignor to The Standard Oil Co. A reaction product of about 15 to about 44 parts by weight of phosphorus pentasulfide, about 25 to about 75 parts by weight of an ester selected from the group consisting of hydrogenated sperm oil, babassu oil and degras, and about 25 to 75 parts by weight of a polyolefin selected from the group consisting of polypropenes and polybutenes having a molecular weight within the range from about 145 to about 940, and mixtures thereof, reacted together simultaneously at a temperature in the range of about 250 to about 350 F. to produce an oil-dispersible material suitable for improving the characteristics of a mineral lubricating oil.

RAPID METHOD OF ANALYZING EMULSIONS AND FATTY MINERAL OILS, Patent #2,606,818, S. Spring and L. F. Peale. The steps in the process of determining the amount of unsaponifiable substances in the total oily matter which may be present in oily emulsions and oils, said steps consisting of adding to the oily matter an alkali to react with the saponifiable material therein, and then adding a sufficient quantity of a high specific gravity polyhydric alcohol to keep the saponified matter in solution and to increase the specific gravity of that solution so that the unsaponifiable oily matter separates from the saponified matter, whereby the separated oily matter layer is rapidly and sharply defined for subsequent measurement.

LUBRICATING COMPOSITION, Patent #2,606,872, W. Gasser and P. R. Van Ess, assignors to Shell Development Co. A finished mineral lubricating oil composition composed of mineral lubricating oil and from 1% to10%, calculated as sulfate ash, of a mixture of an oil-soluble alkali metal petroleum sulfonate and an oil-soluble basic alkaline earth metal petroleum sulfonate, said sulfonates being present in a ration of from 2:8 to 4:6 respectively.

WATER IN OIL EMULSIONS CONTAINING 1,2-ALKANEDIOLS AS COUPLING AGENTS, Patent #2,606,874, P. J. Garner and P. A. Winsor, assignors to Shell Development Co. A water in oil emulsion readily dispersible in water consisting essentially of a mineral oil, water, a water-soluble sulfate salt of an aliphatic alcohol containing from seven to eighteen carbon atoms to the molecule, and 1,2-octanediol.

LUBRICANTS, Patent #2,607,732, K. Duchon and F. H. MacLaren, assignors to Standard Oil Co. A lubricant composition consisting essentially of from about 50% to about 95% asphalt, from about 5% to about 30% lead naphthenate and from about 1% to about 20% of an olefin polymer having a molecular weight of from about 500 to about 25,000, said olefin polymer being a polymer of a mono-olefin of less than 6 carbon atoms.

(Lube Lines, Continued from page 231)

It is seldom necessary for small plants to use color or numbering codes to identify lubricants. Sometimes even large plants which use color codes get into difficulty because the colors become dirty and then there is trouble in properly identifying them. The oil refiner's brand names which are clearly stamped on barrels, drums and other containers, have been found to be the best form of identification. In some plants which purchase their lubricants according to their own specifications, the company's specification numbers are used for identification of products.

It should be obvious that grease should not be stored outdoors during months it might become too stiff or hard to be easily handled. Lime-soap greases should not be stored near steam pipes or other places where elevated temperatures prevail. Since most lime-soap greases are combined with a small amount of water, any exposure of the drum to excessively high temperatures may result in the water being evaporated, leaving relatively dry lumpy grease.

It is sometimes difficult to keep grease clean if the drums are kept in an area where dust and dirt are in the air. Every time a drum cover is removed some dirt is attracted to the grease. This also is one serious objection to storing grease drums outdoors. Another objection to outdoor storage of grease is that drum covers are not, as a rule, kept tight after use. During a rainstorm some water inevitably gets into the grease. In some instances this may reduce the lubricating ability of the grease to such a great extent that it becomes worthless and is discarded.

Block greases are usually shipped in wrappers or in boxes. The grease should always be kept in the box and the wrapper should be re-applied after some grease has been cut from the block.

When greases are removed from drums, only splinter-free paddles should be used. Splinters can cause considerable trouble if they get into grease lines, grease guns or bearings.

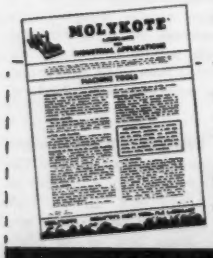
If grease drums are fitted with portable pumps which transfer grease into guns and other receptacles, each pump should be used for a specific type and grade of grease. Some grease always remains in the pump after it is used. Grease mixtures can cause considerable trouble because a mixed product is not generally suited for an application where a specific grease has been recommended.

The basic rules in storing and handling oils and greases should be: keep all products free from water and dirt, keep them away from areas where extremely low or high temperatures prevail, use the same handling equipment for the same products at all times, and instruct the personnel which handles lubricants to be sure that everything likely to be touched by oil or grease is kept clean.

FOR BEARING PRESSURES BEYOND THE CAPACITY OF CONVENTIONAL LUBRICANTS USE

MOLYKOTE®

INDUSTRY'S MOST VERSATILE LUBRICANT



Send for this important bulletin today.

Name.....

Firm.....

Address.....

City..... Zone..... State.....

THE ALPHA CORPORATION

182 Hamilton Avenue Greenwich, Conn.

TECHNICAL COMMITTEE SPONSORSHIP

Re August 1952 issue of LE: Coal Mine Lubrication, by C. W. Thompson, was sponsored by the Technical Committee on Lubrication Equipment; Lubrication and the Load-Carrying Capacity of Gears, by E. T. Hutt, was sponsored by the Technical Committee on Lubrication Fundamentals.

(Moxley, Continued from page 233)

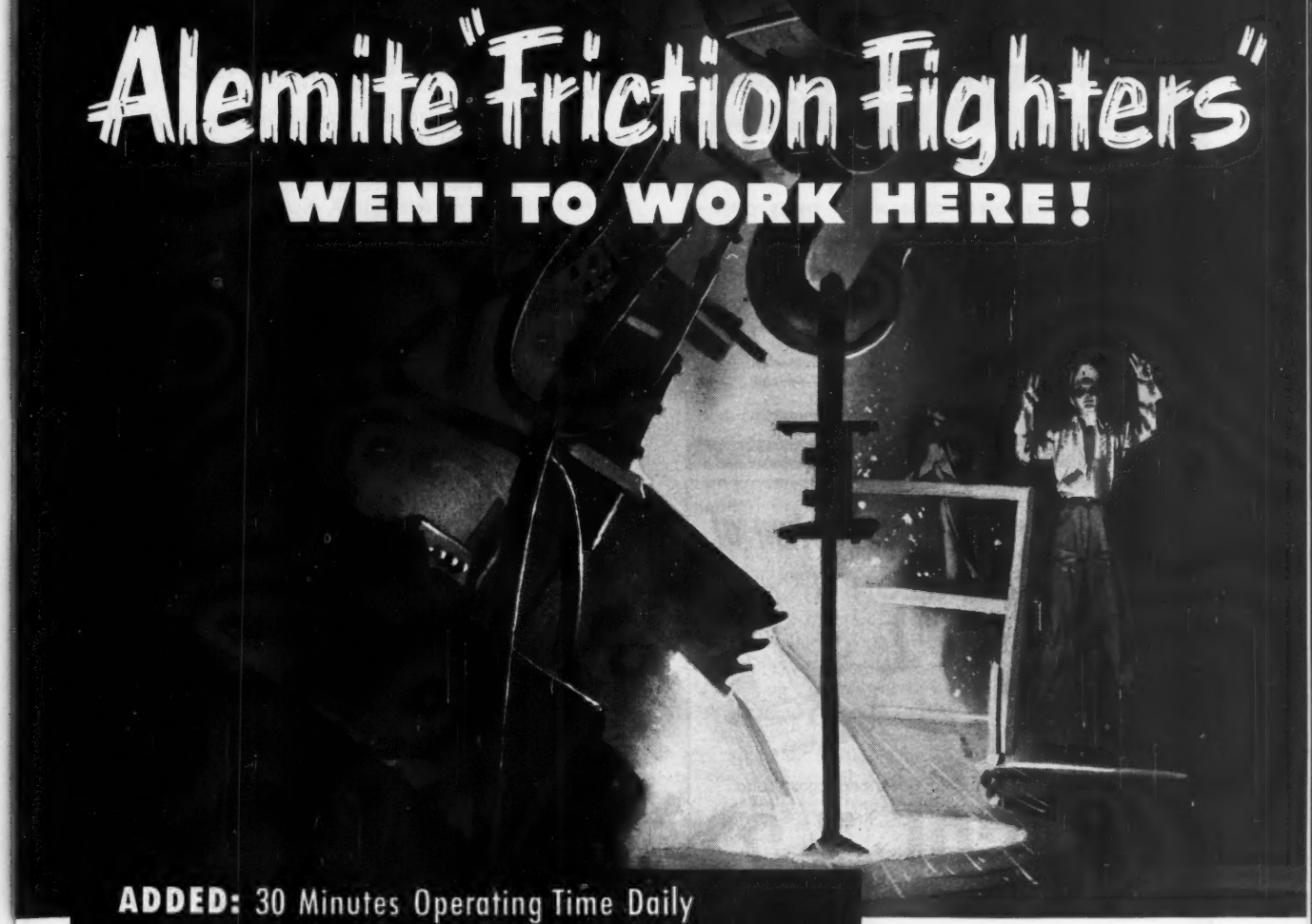
analyzing this subject of personnel organization, let me call to your attention, especially the young men, to look around your respective organization, and you will find that, from natural causes or otherwise, slowly but surely replacements in the management family will be made. You will also find that replacements made from your own management family are much to be preferred to those from an outside source. Herein lies the opportunity for those qualified.

For the moment I would like to direct my remarks to those of you who are entrusted with the selection of those young men brought into the organization as potential supervisors. Herein lines a responsibility, so to speak, first to the selected individual and second to your company. Granting that the qualifications of the selected individual compare favorably with those mentioned above, his progress now depends not only upon his initiative, but more especially his immediate superiors and those of the organization more experienced in the details applicable and common to the position. Herein lines the possibility of success or failure.

Take the time and have the patience to first establish within the individual the confidence within himself that will assure success.

Having considered the building of a supervisory structure, let us be reminded of those individuals who make up the organization of maintenance, application and operation. It has been said that an organization will function with a degree of efficiency comparable to that of supervision. Whether or not this be true, it certainly will be positively reflected in that direction. To plan, schedule and assign the duties of the lubrication and associated departments, demands the continual analysis of individual effort and adaptability of performance personnel, looking forward to a perfected organization of those who can best work and best agree. In order to realize the ultimate of our ambition for perfection in the discharge of our chosen profession, it is imperative that we pattern our lives toward the accepted standards of the golden rule of consideration for others as we would be considered. Our thinking must be motivated by a desire to serve, continually fertilizing our minds with new ideas, with sincere respect and consideration for the opinion of others, and a genuine willingness to share our knowledge and experience with those less informed. The spoken word of recognition and appreciation, in the accomplishment of individual initiative, is the cornerstone

Alemite "Friction Fighters" WENT TO WORK HERE!



ADDED: 30 Minutes Operating Time Daily

ELIMINATED: Bearing Repairs and Oiling Hazards

SAVED: A Total of $2000 Every Year

It Happened in Harrisburg, in a steel plant* where a mammoth traveling crane was required to carry 25 ton loads, make fast stops, quick returns and was under constant threat of friction's wear and tear. To protect it, a variety of lubrication methods were tried and adopted. All proved costly . . . dangerous . . . ineffective.

Then, a trained Alemite "Friction Fighting" specialist was called in to work with the plant engineers. After careful study, an Alemite Mechanized Lubrication System was installed and immediately began to effect savings four ways: 1. In adding 30 minutes additional productive use of the crane daily—valued in cash at $9.00 a day and over $2000.00 per year. 2. Savings of 60% in the amount of grease used. 3. Saving in bearing repairs—none required since the Alemite System was installed. 4. Oiling hazard—completely removed.

You Can Get Similar Results! No matter what size or type of plant you operate, an Alemite Lubrication Engineer can show you dozens of ways of making worthwhile savings through more efficient handling of petroleum products. These are facts which you can readily confirm in your own time studies. The Alemite man will cooperate fully with your plant engineers in setting up a test. Contact your local Alemite Industrial Distributor, or mail coupon below—today!

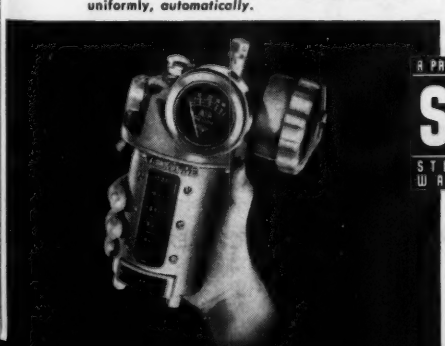
*Name on request

ALEMITE

MEANS EVERYTHING FOR LUBRICATION

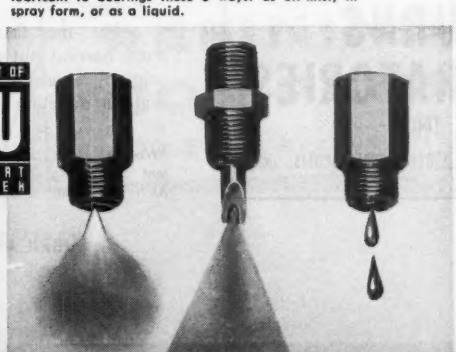
1. Methods 2. Lubricants 3. Equipment

The Alemite "Oil-Mist" Lubricator fights friction by supplying clean, fresh oil for bearings continuously, uniformly, *automatically*.



A PRODUCT OF SW STEWART WARNER

Versatile! Adaptable! The "Oil-Mist" System delivers lubricant to bearings these 3 ways: as oil-mist, in spray form, or as a liquid.



FREE! New Booklet

Please send me:

☐ "11 Ways to Cut Production Costs."

☐ Include Facts on OIL-MIST—the amazing new system that atomizes oil, circulates it to bearings under pressure.

ALEMITE, Dept. P-102
1850 Diversey Parkway, Chicago 14, Illinois

Name.....

Company.....

City..... State.....

TRICO America's Finest
AUTOMATIC OILERS

REPAY THEIR COST MANY TIMES OVER

Provide economy of original installation, cut down time for "trust-to-luck" daily hand oiling, reduce bearing failures and give years of satisfactory performance.

ALL TYPES . . . ALL SIZES AVAILABLE

Constant Level—Gravity—Wick Feed
Under-feed-Thermal-Bottle
Multiple Feed (Manual and Solenoid)
Sump—Oil Cup and Gauge—Special

FREE CATALOG ON REQUEST

TRICO FUSE MFG. CO. Milwaukee, Wis.

the answer to your problem of

LOWER PER-GALLON CUTTING OIL COSTS

A sulphurized chlorinated polarized compound

CRESOL Z-2

SPECIAL

Developed by chemistry. Proved by industry.

TYPICAL ANALYSIS

CHLORINE 13%
SULPHUR 10%
FAT 30%

Used in hundreds of America's metal industries for the machining of all commercial steels and metals, irrespective of alloying constituents and machinability.
Competes with highly rated, specialized conventional cutting oils for specific and general use. Assures maximum performance in terms of tool life, finish and maintenance of size.

Example:

add— 5 gallons Cresol Z-2 Special
— 95 gallons light mineral oil.

result—100 gallons of highly efficient, transparent, low cost, cutting oil suitable for the toughest jobs, stainless steel, etc.

Send for Our Brochure

BURNS LABORATORIES INC.

514 W. WYOMING STREET, INDIANAPOLIS, IND.

of a structure devoted to unity of purpose, especially that of human relations.

The selection of management personnel in industry, and especially in the steel industry, is the combined function of the Personnel Department, Production and Maintenance Department Supervision. Graduate Engineers from several technical colleges are selected. A thorough explanation of the steel business and the adopted training program is presented to those selected. An individual must have either a Bachelor of Science degree in some type of Engineering, or he must have demonstrated unusual abilities during his employment with the Wheeling Steel Corp., with definite aptitude for supervisory or technical work.

Graduate Engineers, as mentioned above, are entered into an organized training period of two years, and are assigned to the several departments applicable to that branch of engineering. They are trained under the tutelage and supervision of the heads of the several departments included in the program. These trainees are identified as Practice Engineers. From this group, or from those who have demonstrated unusual abilities, selections are made for the positions of Assistant Lubricating Engineers, or Lubricating Engineers, as well as other departmental supervision, as the case may be.

The attached chart shows graphically comparative lubrication and maintenance costs for one plant of the Wheeling Steel Corp. from 1940 to 1951. Using 100% in 1940 as a basis for lubrication cost per ton, maintenance cost per ton, and average wage rate per hour, and 100% in 1942 as a basis of lubricant cost per pound and lubricants consumed per ton of steel rolled, it can be seen that the average lubrication cost (1) has been reduced 38% while the cost of lubricants (3) and the wage rate (5) have increased 39.5% and 134% respectively. The quantity of lubricants consumed per ton of steel (4) has been reduced 47% in this same general period. It is also interesting to note that the maintenance cost (2), which is directly dependent upon effectiveness of a lubrication program, has risen only 101% although the wage rate (5) has risen as indicated and the cost of materials for repairs has increased 300 to 400%. This last factor was not plotted since no exact figures could be obtained for it.

In conclusion we must ever bear in mind that our contribution in the enlightenment of those entrusted to our supervision, and the practical application of lubrication engineering is an obligation voluntarily accepted, upon which depends the success of the enterprise in which we are engaged. Therefore, in the spirit of sincerity and a will to do a better job, let us take an inventory of our capacity as practical engineers in the discharge of our several assignments, and, not of less importance, our ability in the evaluation of human relationship.

(Sonntag, Continued from page 234)

The non-appearance of the problem of bacterial growth and scum formation in earlier years is attributed to lower rainfall and a lower level of ground water. The rainfall in 1950-1951 was considerably greater than before and the ground water level rose accordingly. This ground water, with polluted waters and fecal drains, infiltrated into the system through the concrete walls of the cistern and accumulator.

After the first three recommendations, listed above, were carried out in detail, all trouble ceased even with the original emulsifying agent and the system now operates without difficulty.

REFERENCE

[1]Waniek, Hans, J Sonnenschein, C.: Investigation of the Bacteria Content of Cooling and Lubricating Oils in the Metal Fabricating Industry. Arch. Ind. Path. u. Ind. Hygiene, 12 (no. 1), 35-80, 1943.

(Roubik, Continued from page 237)

decrease in tool life provided that the setup conditions, cutting speed, and feed remained constant.

When milling harder steels, a reduction in cutting speed and feed per tooth increased the tool life in terms of volume of metal removed.

Carbide face-milling of medium-carbon steels at any hardness with application of 40:1 water-soluble oil emulsion was not only inconvenient but impractical since no improvement in surface finish resulted, tool life was actually decreased, greatly in some instances, and tool failure was much more likely to be of an objectionable type. Complete flooding of the tool and workpiece by immersion generally resulted in the worst performances.

Further tests of this nature with straight cutting oils and high pressure nozzles would be desirable to determine whether or not a different type of fluid or method of application would improve surface finish, tool life, or type of tool failure.

REFERENCES

[1]Armitage, J. B., & Schmidt, A. O.: Influence of Steel Hardness in Face-Milling. Transactions A.S.M.E., Vol. 71, No. 5, 1949, pp. 413-419; American Machinist, Vol. 93, No. 3, Feb. 10, 1949, pp. 98-99.

[2]Schmidt, A. O.: Determining Tool Forces in High-Speed Milling by Thermo-analysis. Mechanical Engineering, Vol. 66, 1944, pp. 439-442; Mechanical World, Vol. 116, Sept. 15, 1944, pp. 301-303.

[3]Armitage, J. B., & Schmidt, A. O.: An Investigation of Radial Rake Angles in Face Milling. Transactions A.S.M.E., Vol. 66, 1944, pp. 633-643.

[4]Schmidt, A. O.: Economy Factors in Carbide Milling. The Iron Age, Vol. 161, May 27, 1948, pp. 72-77.

[5]Armitage, J. B. & Schmidt, A. O.: Radial Rake Angles in Face Milling. Mechanical Engineering, Vol. 67, 1945, pp. 453-456; Canadian Machinery and Manufacturing News, Vol. 56, Oct., 1945, pp. 81-84 and 156.

[6]Schmidt, A. O., & Sirotkin, G. V. B.: Effect of Cutting Fluids and Power Requirements in Metal Cutting Operations. Lubrication Engineering, Vol. 4, No. 6, Dec., 1948, pp. 261-265.

[7]Iwascheff, Wackch: Coolant Flood Improves Carbide Performance. The Iron Age, Vol. 168, No. 3, July 19, 1951, pp. 112-114; Nassdrehen mit Hartmetall-Schneidplatten. Werkstatt und Betrieb, Vol. 81, No. 9, 1948, pp. 252-255.

[8]Cutter Research, California Institute of Technology. War Production Board Data Sheets, Oct. 20, 1945, Sheets 13, 15, and 16, CR-39, pp. 1, 3, and 4.

[9]Boston, O. W.: Metal Processing. John Wiley & Sons, Inc., New York, N. Y., Second Edition, 1951, p. 224.

[10]Schmidt, A. O., & Roubik, J. R.: Milling Hot Workpieces. The Tool Engineer, Vol. XXIII, No. 6, Dec., 1949, pp. 17-19; Automotive Industries, Vol. 101, No. 9, Nov. 1, 1949, pp. 29-31, 67.

[11]Pigott, R. J. S., & Colwell, A. T.: Hi-Jet System for Increasing Tool Life. SAE Paper No. 706, presented at Annual Meeting, Jan. 15, 1952.

[12]Lauterbach, W. E., & Ratzel, E. A.: Investigation of Flow and Effect of Cutting Oil in Machining Operations. Lubrication Engineering, Vol. 7, No. 1, Feb. 1951, pp. 15-19.

ACKNOWLEDGEMENT

Grateful acknowledgement is made to Dr. A. O. Schmidt, Kearney & Trecker Corp., for his advice and encouragement in this work.

(Lauterbach-Ratzel, Continued from page 240)

annealed steel is almost 80 per cent lower than that for cutting dry. The depth of cold work in SAE 52100 annealed steel produced by a dry cut is approximately 12½ times the depth of cut.

The depth of cold work gives a semi-quantitative measure of the severity of cold work[2]. Therefore, from a practical viewpoint, the use of a cutting oil which decreases effectively the depth of cold work would be expected to prolong the useful life of the tool by (1) reducing the amount of work which goes into the deformation of the workpiece, thus decreasing the resultant force on the tool, and (2) reducing the hardness of the finish surface, thus decreasing the abrasive effect on the tool during subsequent cuts.

MEASUREMENT OF DEPTH OF COLD WORK AS A METHOD FOR EVALUATING CUTTING OILS: A comparison of the experimental data obtained from these tests with an independent effectiveness rating of the cutting oils shows that an inverse relationship exists between the depth of cold

work in the workpiece and the relative effectiveness of the several oils when cutting at 2.5 fpm. It is concluded that depth of cold work determinations, such as those illustrated in Fig. 6, afford a method for the laboratory evaluation of cutting oils which are to be used in low-speed machining operations.

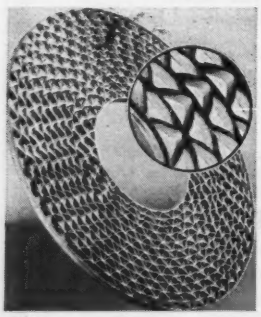
The five oils used in these tests were rated independently by Shell Oil Co. from the least effective to the most effective in the following order: (1) Oil No. 9; (2) Oil No. 33; (3) Oil No. 6 or Oil No. 5; (4) Oil No. 3. The relative ratings of oils No. 9. 33, 6, and 5 were based on extensive field experience in low-speed metal cutting operations. Oil No. 3 was an experimental oil which had not as yet been employed in commercial applications; however, several laboratory tests had indicated that this oil would be more effective in low-speed operations than any of the other four oils.

It can be seen in Fig. 9 that, if the oils are classified in the order of decreasing depths of cold work for any given rake angle (as, for example. 21 deg.), their relative order will be the same as that given in the Shell Oil Co. effectiveness rating. That is, the least effective oil accompanies the largest depth of cold work and the most effective oil accompanies the smallest depth of cold work for cutting at 2.5 fpm under the given set of cutting conditions. From this observation, it appears that the depth of cold work which accompanies the use of a specified cutting oil gives a measure of the relative effectiveness of this oil in low-speed operations.

REFERENCES

[1]Thomassen, L. and McCutcheon, D. M.: X-Ray Determination of Depth of Cold Working by Machining. Mech. Eng., LXVI, 155 ff., March, 1934.
[2]Zankl, F., Barkow, A. G. and Schmidt, A. O.: X-Ray Diffraction as a Gage for Measuring Cold Work Produced in Milling. Trans. ASME, LXXIX, 307 ff., May, 1947.

thinking of PM* ? . . . . .



Don't overlook the FRANTZ FERROFILTER® Magnetic Separator

* PREVENTIVE MAINTENANCE

Here's one of a stack of strongly magnetized grids, the hard-working heart of a FRANTZ FERROFILTER. These grids comb and re-comb iron and steel chips and particles out of coolants and cutting oils; lubricating and hydraulic oils. This gives your cutting tools longer life — higher output between grinds. It reduces abrasion of pumps, valves, gears, bearings and other surfaces subject to wear in your production equipment.

Send for BULLETIN 50

for application and installation data; types and sizes of these permanent magnet separators.

S. G. Frantz Co., Inc.
P. O. Box 1138 Trenton 6, N. J.
Manufacturers of Permanent Magnet and Electromagnetic Separators

ACKNOWLEDGEMENT

Grateful acknowledgement is made to Mr. Seichi Okubo, of Armour Research Foundation, for his able assistance in conducting this investigation, and to Mr. Stanley Siegel, formerly of Armour Research Foundation, for his advice on the use of x-ray diffraction techniques.

(Godfrey-Bisson, Continued from page 243)

For the steel ball-glass flat combination, the clean specimens fretted in from 1 to 30 cycles and the specimens lubricated with mineral oil fretted in 1500 cycles. The MoS_2 film applied by dusting showed fretting in 72,000 cycles while the well-bonded Mos_2 film delayed fretting for a total of 28,000,000 cycles. Even after being subjected to this great number of cycles, the coating was not greatly damaged although it was sufficiently worn to expose metal and allow the first stage of fretting to take place.

Other methods of application of MoS_2 not reported in Table I included mixtures of MoS_2 with liquid (water or mineral oil) or semi-liquid (greases) vehicles. Fretting experiments produced results somewhere between those obtained for the dusted MoS_2 film and those obtained for the bonded MoS_2 film.

In general, the trends obtained with the steel ball-glass flat combination were confirmed with the steel flat-steel flat combination.

The results of this limited investigation of fretting inhibitors shows that, of the methods employed, the best by far was the bonded MoS_2 coating. While all methods employed were beneficial because they served to decrease the strong adhesive forces between the surfacs (which forces have been shown to be responsible for surface damage by fretting), the most effective films were those which had the strongest resistance to being removed from between the surface.

SUMMARY

The results of an investigation of the basic mechanism of fretting and preliminary experiments on principles of mitigation of fretting may be summarized as follows: 1. Fretting is initiated by the loosening, due to inherent adhesive forces, of extremely finely divided and apparently virgin material that is extruded from the contact area and reacts with oxygen simultaneously; 2. The fretting of platinum, glass, quartz, ruby, and mica relegated the role of oxidation as a cause to that of a secondary factor; 3. Fretting readily occurred between clean nonmetals and metals. Steel balls vibrating in contact with glass microscope slides provided an excellent method for observing fretting; 4. The occurrence of fretting in ½-cycle of vibration indicates that alternation of motion is not necessary to initiate fretting and thus fatigue (in the usual sense) does not cause fretting; 5. Fretting can be mitigated most effectively by use of solid, tenacious, low shear strength materials between the vibrating surfaces (to reduce adhesion). A solid lubricating film of resin-bonded MoS_2 was effective in delaying occurrence of fretting.

REFERENCES

[1]Anon.: The Corrosion Handbook, Herbert H. Uhlig, Ed. John Wiley & Sons, Inc., 1948, pp. 590-597.
[2]Tomlinson, G. A., Thorpe, P. L., & Gough, H. J.: An Investigation of the Fretting Corrosion of Closely Fitting Surfaces. Proc. Inst. Mech. Eng., Vol. 141, 1939, pp. 223-249.
[3]Sakmann, B. W., & Rightmire, B. G.: An Investigation of Fretting Corrosion under Several Conditions of Oxidation. NACA TN 1492, 1948.
[4]Morton, Hudson T.; Friction Oxidation. The Fafnir Bearing Co. (New Britain, Conn.).
[5]Godfrey, Douglas: Investigation of Fretting by Microscopic Observation. NACA Report 1009, 1951.
[6]Godfrey, Douglas, & Bisson, Edmond E.: Effectiveness of Molybdenum Disulfide as a Fretting Corrosion Inhibitor. NACA TN 2180, Sept. 1950.
[7]Godfrey, Douglas: Preliminary Investigation of Fretting. NACA Tech. Film 23. (Available upon request from NACA Headquarters Office, Washington, D. C.)
[8]Bowden, F. P., & Tabor, D.: The Friction and Lubrication of Solids. Oxford Univ. Press, 1950, pp. 312-314.

[9]Boyd, John, & Robertson, B. P.: The Friction Properties of Various Lubricants at High Pressures. Trans. ASME, Vol. 67, No. 1, Jan. 1945, pp. 51-56; discussion, pp. 56-59.
[10]Johnson, Robert L., Godfrey, Douglas, & Bisson, Edmond E.: Friction of Solid Films on Steel at High Sliding Velocities. NACA TN 1578, 1948.
[11]Godfrey, Douglas, & Nelson, Erva C.: Oxidation Characteristics of Molybdenum Disulfide and Effect of Such Oxidation on Its Role as a Solid-Film Lubricant. NACA TN 1882, 1949.

(Strohecker, Continued from page 250)

was satisfactory in the range of 0 to 10 F., with the general comment that this grease is used below 15 F. Grease I—The opinion on this grease is divided, with five dealers indicating satisfactory use below 32 F. and five indicating that its performance was unsatisfactory below 32 F. Various other comments indicated that the range of satisfactory operation for this grease was between 32 and 15 F. Grease J—All comments indicated that this grease was not satisfactory below 32 F.

In addition to the comments regarding actual pumpability. there were three indications given that working conditions were too cold to carry out work below 32 F.

When the foregoing comments on the pumpability of these three greases and the comparison of the failing temperatures obtained in this test work are tabulated, it is found that there is fairly good agreement between them: Grease J —Temperature range from survey down to 32 F., Average automotive fitting—(10 g./min.) failing temperature 28 F. Grease I—Temperature range from survey 15-32 F., Average automotive fitting—(10 g./min.) failing temperature 24.5 F. Grease H—Temperature range from survey below 15 F., Average automotive fitting—(10 g./min.) failing temperature 10.5 F.

CORRELATION OF ACTUAL PUMPING DATA WITH LABORATORY EQUIPMENT

It is generally recognized that it would be desirable to have some laboratory method available which would enable the prediction of the low temperature pumpability characteristics of greases. For instance, the determination of these characteristics in actual air-operated equipment requires a time interval of four weeks; it is further necessary to prepare 35 pounds of grease for the testing. Because of these factors, it is apparent that a laboratory-evaluating device requiring both less time and smaller quantities of grease would be of definite value.

Previous work on this subject indicated that the flow characteristics of greases as determined by the pressure viscosimeter (ASTM Method D-1092-50-T) were indicative of the dispensing characteristics in various types of pumps.

J. C. Zimmer and J. B. Patberg ("Notes on the Operation and Application of the S.O.D. Pressure Viscosimeter-Grease Dispensing Tests at Low Temperatures," *Institute Spokesman*, August, 1945) conducted correlation tests between the pressure viscosimeter and a constant-pressure dispensing unit. From this work they concluded that at a rate of shear of 165 reciprocal seconds the limiting apparent viscosity was 3,000 poises. Thus, the lowest pumpable temperature of greases in their pump could be determined from pressure viscosimeter data.

The data made available by the test work conducted with air-operated service station type pumps at Beacon Laboratories offered the basis from which additional correlation work could be conducted.

PUMPING DATA VERSUS APPARENT VISCOSITY METHOD OF CORRELATION

A general description of the principles underlying the method of correlation between pumpability and the apparent viscosity of greases is given as follows:

The air-operated grease pumps are essentially constant-pressure devices, as the motivating force, that is, the air supply pressure, is maintained at a given pressure throughout the testing. The grease flows, when being pumped, through various cylindrical passages of different lengths. These passages can be considered as capillaries. Thus, the air-operated pumps can be thought of as a type of viscosimeter with the rate of flow of grease through the pumps dependent upon apparent viscosity.

The apparent viscosity of greases exhibits the property of being dependent not only upon temperature but also dependent on the rate of shear. When greases are dispensed by a pump, the dependency of apparent viscosity on temperature creates a varying delivery rate. Because of this varying delivery through the pump, the effective rate of shear is not constant throughout the test temperature range and consequently, this factor offers complications in the correlation of pumpability and apparent viscosity. Therefore, it is necessary to eliminate the rate of shear as a variable in order to carry out the desired correlation.

The rate of shear may be eliminated by arbitrarily selecting a given delivery rate through the pump as a criterion to compare the various greases and to correlate their apparent viscosity with their pumpability. As has been discussed in a previous section, various failing criteria based on different delivery rates have been selected to interpret the dispensing test results.

The primary purpose of this correlation is the determination of some simple laboratory method whose data will be indicative of the relative pumpability characteristics of greases. Therefore, it is believed necessary to choose only one failing criterion upon which the correlation can be established. The 50-gram-per-minute nominal free-flow condition has been arbitrarily selected as this primary basis.

Grafo COLLOIDAL GRAPHITE
INDUSTRIAL PRODUCTION
for—HOT or COLD FORGING, DRAWING AND STAMPING • ASSEMBLY and RUN-IN • HIGH and LOW TEMPERATURES • IMPREGNATION and PARTING • ALL RUBBING and SLIDING SURFACES.
"Grafo" Colloidal Graphite may be obtained in water, petroleum oil and castor oil, in concentrated, semi-concentrated and ready-for-use mediums.
Write Us Regarding Your Special Applications
PRODUCE MORE—FASTER—BETTER
GRAFO COLLOIDS CORPORATION
Other Industrial Uses:
DIE CASTINGS
MOLD COATINGS
STEAM CYLINDERS
WIRE DRAWING
PARTING COMPOUNDS
IMPREGNATION
PLASTICS
CORROSION RETARDANT
RESISTANCE ELEMENTS
STATIC CONTROL
CONDUCTIVE COATINGS
EXTREME PRESSURES
360 WILKES PLACE
SHARON, PENNSYLVANIA

For the different greases the temperatures at which the given failing delivery is reached will vary because of differences in the flow properties of the greases. Therefore, if the greases are tested in the pressure viscosimeter, the apparent viscosities at different temperatures for one rate of shear may be obtained. Utilizing these data, a plot is made of apparent viscosity versus temperature. For example, consider Fig. 4. On these curves the failing temperatures as determined by the pumping tests of the respective greases may be superimposed. The close agreement of the superimposed failing temperature points about a single value of apparent viscosity is an indication of the degree of agreement between the pumpability results and the apparent viscosity of the greases at that rate of shear.

SELECTION OF RATE OF SHEAR FOR FAILING CONDITION

The selection of the rate of shear at which the apparent viscosity data is determined can be arrived at by one of two methods. The first is to utilize an oil and perform pumping tests in the actual equipment. From the knowledge of the viscosity of the oil and the various lengths within the actual pumping mechanism. the effective radius occurring in the pump may be calculated for the failing criterion. From the calculated effective radius, the rate of shear for the failing criterion may also be calculated, thus establishing one rate of shear to be utilized in the correlation.

The second method is a trial-and-error solution consisting of plotting apparent viscosity versus temperature for various greases with different rates of shear as parameters. That rate of shear at which the superimposed failing temperatures for the same greases indicate close agreement about a single value of apparent viscosity is selected as the rate of shear against which further correlation can be conducted.

Both of the foregoing methods were investigated with the trial-and error solution found to be the more satisfactory correlation method.

Multiple and Single
AUTOMATIC
LUBRICATION
SOLENOID OPERATED
FOR MACHINE TOOLS, PUNCH PRESSES, PRINTING PRESSES, CONVEYORS, ETC.
LUBRICATION OF UP TO 24 HARD-TO-REACH BEARINGS STARTS WITH MOTOR SWITCH
Solenoid is connected across line of driving motor . . . and lubrication starts when motor switch is turned on. Single reservoir replaces many individual oilers. Smooth, easy hair-line adjustments on each feed valve through use of friction screw.
FOR ANY LUBRICATION PROBLEM . . . ask for our engineering suggestions
OIL-RITE ELECTRO OILER
OIL-RITE CORPORATION
2328 WALDO BOULEVARD
MANITOWOC, WISCONSIN

TRIAL-AND-ERROR SOLUTION

Previous work (Lubrication, September, 1950) on the correlation of pumpability with Pressure Viscosimeter data was made purely on a trial-and-error basis. This work consisted of selecting different rates of shear and making a plot of the apparent viscosities of the various greases at the selected rates of shear versus temperature. On these plots the failing temperatures as determined by the 50-gram-per-minute nominal free-flow failing condition in the actual dispensing units were superimposed on the curves. Of the numerous shear rates treated in the foregoing matter, it was found that for a rate of shear of 205 reciprocal seconds and a limiting apparent viscosity of 900 poises, the minimum amount of scattering of the points occurred. The rate of shear of 205 reciprocal seconds is given by one of the ASTM pressure viscosimeter capillaries and is, therefore, ideal in that the test time may be cut down. The grease need only be tested through the single capillary.

Fig. 4 illustrates the apparent viscosity versus temperature data for the numerous greases tested with the failing temperature points indicated as circles. Considering the correlation established with the limiting apparent viscosity of 900 poises, the predicted failing temperatures for all of these greases was determined from curves of this nature.

These data compared with the actual failing temperature are given on Table IV.

These data may also be treated mathematically by the method of Least Squares to determine the equation of the line, the mean square deviation, and the degree of correlation. The data have been plotted on Fig. 5 which also shows the results of the various calculations.

It can be readily recognized that the degree of correlation ($r^2 \times 100$) of 93.1 per cent found for the condition of 205 reciprocal seconds and a limiting apparent viscosity of 900 poises is ideal. It is, therefore, concluded that a satisfactory correlation between the pressure viscosimeter and the dispensing units tested exists for pressure visvosimeter conditions of 205 reciprocal seconds, a limiting apparent viscosity of 900 poises, and a pump-failing condition of 50-grams-per-minute under nominal free flow.

CORRELATION OF OTHER FAILING CONDITIONS

It has been shown that a satisfactory correlation exists between the pressure viscosimeter and pumpability data taken under one failing criteria (50 g./min. nominal free flow). This, of course, enables the determination of one failing temperature by the pressure viscosimeter. The comparison of this failing temperature for the different greases will reveal the relative pumpability characteristics of the different greases.

However, the failing temperatures for the greases under other failing criteria are also desirable, particularly for field applications. It was considered feasible to develop this information by relating the failing temperature as predicted by the pressure viscosimeter for a 50-gram-per-minute free-flow condition with the actual failing temperatures under other pumping failing conditions which have been discussed previously.

Utilizing the data given on Table III and the predicted failing temperatures for the 50-gram-per-minute condition given on Table IV, the straight lines through the points were again determined by the method of Least Squares. The equation of the lines, mean square deviations, and degrees of correlation for the various cases are given on Table V. Examination of the degree of correlation shows that generally satisfactory agreement exists between the predicted 50 g./minute free-flow failing temperature and the actual failing tempera-

ture under other failing conditions. The degree of correlation of 0.796 between the actual 10 g./minute loose shackle and the predicted 50 g./minute free-flow condition is lower than for the other cases, but is considered high enough to be of definite value.

The foregoing brings out that the failing temperatures under other conditions may be predicted from the 50 g./minute free-flow failing temperatures obtained from pressure viscosimeter data. It is not necessary, however, to utilize the curves or equations to obtain this information. The equations of the lines permit the construction of nomographs relating the various failing temperatures to the 50 g./minute predicted failing temperature. These nomographs are shown on Fig. 6.

PUMPING TESTS VERSUS PENETRATION

The popular conception that the pumpability of greases is related to their consistency as measured by ASTM penetration was evaluated. The ASTM unworked consistencies of the various products were determined over the temperature range encountered in the determination of their pumpability. From these data applicable penetrations were taken for the 50-gram-per-minute free-flow failing temperatures. The average failing penetration of 125 was then used to predict failing temperatures. The actual failing temperatures and predicted failing temperatures were treated mathematically using the method of least squares to determine the best straight line through the points.

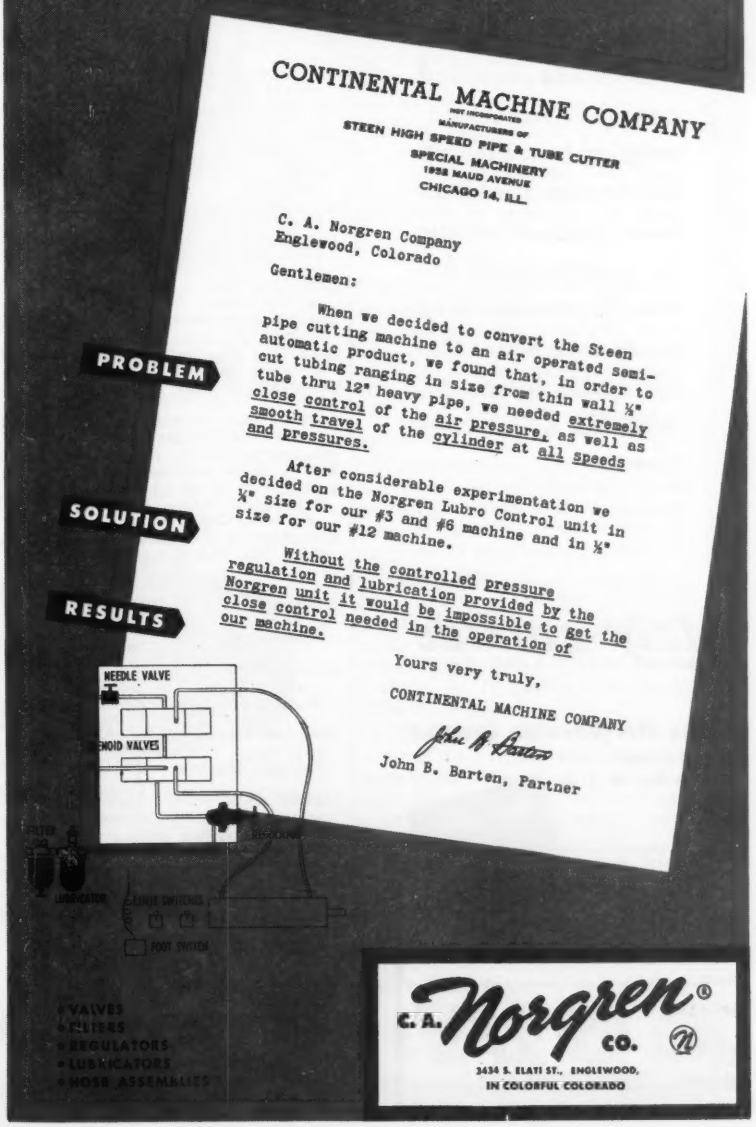
From the low degree of correlation, 37.9 per cent, found by comparison of actual and penetration predicted failing temperatures, it can be readily appreciated that the use of penetration values to predict the dispensing characteristics of a grease is not satisfactory.

POSITION OPEN
for
MECHANICAL
AND
LUBRICATION
ENGINEER

Excellent opportunity for one who is thoroughly familiar with Ball and Roller Bearings. A college graduate in Mechanical Engineering preferred. At least five years actual experience in general industry. Willing to travel. Salary open. Write Box LE-2 giving full details and qualifications in first letter.

LUBRICATION ENGINEERING
343 S. Dearborn Street
Chicago 4, Illinois

NORGREN regulator-lubricator setup solves precision control problem on pipe cutter


CONTINENTAL MACHINE COMPANY
NOT INCORPORATED
MANUFACTURERS OF
STEEN HIGH SPEED PIPE & TUBE CUTTER
SPECIAL MACHINERY
1958 MAUD AVENUE
CHICAGO 14, ILL.
C. A. Norgren Company
Englewood, Colorado
Gentlemen:
When we decided to convert the Steen pipe cutting machine to an air operated semi-automatic product, we found that, in order to cut tubing ranging in size from thin wall ⅛" tube thru 12" heavy pipe, we needed extremely close control of the air pressure, as well as smooth travel of the cylinder at all speeds and pressures.
PROBLEM
After considerable experimentation we decided on the Norgren Lubro Control unit in ¼" size for our #3 and #6 machine and in ½" size for our #12 machine.
SOLUTION
Without the controlled pressure regulation and lubrication provided by the Norgren unit it would be impossible to get the close control needed in the operation of our machine.
RESULTS
Yours very truly,
CONTINENTAL MACHINE COMPANY
John B. Barten, Partner
NEEDLE VALVE
SOLENOID VALVES
LUBRICATOR
LINE SWITCH
FOOT SWITCH
• VALVES
• FILTERS
• REGULATORS
• LUBRICATORS
• HOSE ASSEMBLIES
C. A. Norgren CO.
3434 S. ELATI ST., ENGLEWOOD,
IN COLORFUL COLORADO

What do you know about the

Moly-sulfide
A LITTLE DOES A LOT

LUBRICANT?

You may have heard about a highly successful solid-film lubricant which is giving remarkable results in the shop and in the field.

In one 40-page booklet we have collected 154 detailed case-histories describing how difficult lubrication problems have been overcome by molybdenum sulfide. If you wish to be up to date about this solid-film lubricant, write for a free copy now.

THE LUBRICANT OF MANY USES

Moly-sulfide
A LITTLE DOES A LOT

Climax Molybdenum Company
500 Fifth Avenue
New York City · 36 · N · Y ·

SEND FOR THIS FREE BOOKLET TODAY

Name.....
Position.....
Company.....
Address.....

LE-10 MS3a

ASLE DIRECTORY

SECTION OFFICERS

Section	Chairman	Vice-Chairman	Secretary	Treasurer
BALTIMORE	W. Rosenberg	W. C. Landis	V. J. Ryan	V. J. Ryan
BOSTON	E. R. Booser	J. P. Ruchinskas	A. S. McNeilly	E. M. Higgins
BUFFALO	W. H. Millett	E. W. Chapman*	R. J. Torrens	S. S. Burgess
		W. G. Belfryt		
CHICAGO	W. G. Fatch	F. J. Scott	A. S. Two	A. S. Two
CINCINNATI	W. D. Whalen	C. C. Weymiller	R. A. Clark	R. A. Clark
CLEVELAND	R. Sipple	R. R. Slaymaker	R. H. Josephson	A. O. Anderson
CONNECTICUT	A. F. Green	D. H. Van Vleck	J. S. Martin	J. S. Martin
DAYTON	V. C. Hutton	A. H. Turner	D. M. Forinash	R. H. Ball
DETROIT	J. W. Swain, Jr.	M. L. Beardslee	R. Urso	J. A. Brady
EVANSVILLE	W. C. Kerney	O. Daussman	E. Peak	E. Peak
FORT WAYNE	R. L. Gruenert	J. W. Sites	J. H. Wright	J. H. Wright
INDIANAPOLIS	R. Filipczak	E. D. Harkins, Sr.	R. C. Fatout	R. C. Fatout
KANSAS CITY	C. A. E. Gower	E. R. Allgeyer	C. C. Schrotberger	C. C. Schrotberger
KINGSPORT	W. L. Bradshaw	C. L. Peterson	J. E. Fleenor	J. E. Fleenor
LOS ANGELES	F. H. Ott	E. A. Mohr	R. C. Dishington	R. C. Dishington
MILWAUKEE	G Travers	J. R. Schidrowitz	R. W. Schroeder	M. R. Skirvin
NEW YORK	J. J. Scott	A. M. Southcott	E. Landau	O. W. Wuerz
N. CALIFORNIA	S. R. Calish, Jr.	J. A. Lettier	P. M. Ruedrich	P. M. Ruedrich
ONTARIO	T. A. Marshall	A. F. Thorburnt	B. P. Malley	W. B. Dembner
		K. E. McHenry*		
PHILADELPHIA	J H. Dunigan	J. L Parsons	R. J. Simes	L. W. Miller
PITTSBURGH	A. A. Raimondi	M. S. Hough	F. R. Ross	F. R. Ross
SAGINAW VALLEY	D. W. Benner	J. C. Grenier	D. H. Buell	S. O. Kimball
ST. LOUIS	A. L. Heintze	J. B. Davis	M. J. Croghan, Jr.	G. M. Daily
SYRACUSE	T. F. Dundon	H. E. Kave	R. Buyea	S. B. Krutulis
TWIN CITIES	B. T. Harding	J. H. Richards	W. H. Furst	F. E. Blanco
WHEELING	J. D. Lykins	R. G. Call	W. P. Liller	D. Ulman
YOUNGSTOWN	E. F. Boron	J. P. Halwachs	R. S. Scheidemantel	W. P. Liller

* (U.S.A.) † (Canada)

ADDRESSES OF SECTION SECRETARIES

BALTIMORE—V. J. Ryan, 2003 E. 43rd St., Baltimore 18, Md.

BOSTON—A. S. McNeilly, 71 Lincoln St., Melrose 76, Mass.

BUFFALO—R. J. Torrens, Eastman Kodak Co., Kodak Park Rochester, N. Y.

CHICAGO—A. S. Two, 3201 S. Wenonah Ave., Berwyn, Ill.

CINCINNATI—R. A. Clark, Sun Oil Co., 2414 River Rd., Cincinnati 4, Ohio.

Cleveland—R. H. Josephson, Cleveland Graphite Bronze Co. 17000 St. Clair Ave., Cleveland 10, Ohio.

CONNECTICUT—J. S. Martin, 119 Roanoke Ave., Fairfield, Conn.

DAYTON—D. M. Forinash, 918 Albert St., Dayton 9, Ohio.

DETROIT—R. Urso, McCord Corp., E. Grand Blvd. & Riopelle, Detroit 11, Mich.

EVANSVILLE—E. Peak, Light Plant, Henderson, Ky.

FORT WAYNE—J. H. Wright, Sun Oil Co., 4900 N. Clinton St., Fort Wayne 8, Ind.

INDIANAPOLIS—R. C. Fatout, Alvord Oil Co. 1501 S. Senate, Indianapolis 2, Ind.

KANSAS CITY—C. C. Schrotberger, ASLE, Room 1511, Federal Reserve Bank Bldg., 925 Grand Ave., Kansas City 13, Mo.

KINGSPORT—J. E. Fleenor, Tennessee Eastman Corp. Bldg. 54-A, Kingsport, Tenn.

LOS ANGELES—R. C. Dishington, General Petroleum, 2721 E. 37th St., Los Angeles, 58, Calif.

MILWAUKEE—R. W. Schroeder, 324 Waukesha Ave,. Sussex, Wis.

NEW YORK—E. Landau Asiatic Petroleum Corp., 655 Fifth Ave., New York, N. Y.

NORTHERN CALIFORNIA—P. M. Ruedrich, Griffin Chemical Co., 100 6th St., San Francisco 7, Calif.

ONTARIO—B. P. Malley, Shell Oil Co. of Canada, Ltd. 25 Adelaide St. E., Toronto, Ont., Canada.

PHILADELPHIA—R. J. Simes, W. Valley Ave., Atglen, Pa.

PITTSBURGH— F. R. Ross, Alemite Co. of Pittsburgh, 201 Shady Ave., Pittsburgh 6 Pa.

SAGINAW VALLEY—D. H. Buell, 3222 Osler, Saginaw, Mich.

ST. LOUIS—M. J. Croghan, Jr., Lincoln Engineering Co., 5701 Natural Bridge Ave. St. Louis 20, Mo.

SYRACUSE—R. Buyea, New Process Gear Corp., 500 Plum St., Syracuse 1, N. Y.

TWIN CITIES—W. H. Furst, Western Oil & Fuel Co., 227 Colfax, North, Minneapolis, Minn.

WHEELING—W. P. Liller, Gulf Oil Corp., P. O. Box 32, Wheeling, W. Va.

YOUNGSTOWN—R. S. Scheidemantel, Standard Oil Co. (Ohio), 1315 Poland Ave. Youngstown, Ohio.

NATIONAL COMMITTEE CHAIRMEN

AWARDS
R. K. Ulrich
Bethlehem Steel Co.

BY-LAWS
J. F. Palmer, Jr.
Monsanto Chem. Co.

EDUCATION
D. D. Fuller
Columbia University

FINANCE
W. H. Fowler Jr.
Chairman Ex-Officio
The Pure Oil Co.
J. W. Peterson
Chairman
Standard Oil Co. (Ind.)

INDUSTRIAL MEMBERSHIP
W. P. Youngclaus, Jr.
National Office

HISTORIAN
W. G. Fatch
Carnegie-Illinois Steel Corp.

INDUSTRY RELATIONS
C. H. Foster
Atlantic Refining Co.

MEMBERSHIP AND ADMISSION
T. F. Dundon
Eastern Co-Chairman
Carrier Corp.
J. N. Waddell
Mid-Western Co-Chairman
Henry H. Cross Co.
M. A. Wise
Western Co-Chairman
Gen'l Petroleum Corp.
B. P. Malley
Canadian Co-Chairman
Shell Oil Co. of Canada, Ltd.

NATIONAL MEETINGS
A. S. McNeilly
Annual Meeting (Boston)
Esso Standard Oil Co.

NEW SECTIONS
W. P. Youngclaus, Jr.
National Office

NOMINATIONS
C. E. Schmitz
Crane Packing Co.

PROGRAM
R. H. Josephson
Annual Meeting (Boston)
Cleveland Graphite Bronze Co.

RESEARCH AND PROJECTS
E. M. Glass
Hq. Wright Air Development Center

TECHNICAL COMMITTEES

GENERAL TECHNICAL
T. G. Roehner
Socony-Vacuum Oil Co. Inc.

FLUIDS FOR METAL WORKING
E. L. H. Bastian
Shell Oil Co.

HYDRAULICS AND HYDRAULIC MACHINERY
D. P. Morrell
Ford Motor Co.

LUBRICANT RECLAMATION AND DISPOSAL
D. M. Cleaveland
Bendix Aviation Corp.

BEARINGS AND BEARING LUBRICATION
J. Boyd
Westinghouse Electric Corp.

LUBRICATION EQUIPMENT
A. F. Brewer
The Texas Co.

LUBRICATION FUNDAMENTALS
E. R. Booser
General Electric Co.

PHYSICAL PROPERTIES OF LUBRICANTS
M. L. Langworthy
The Texas Co.

(Lubrication Summarized, from 251)

of the whim or will of the individual who carries the oil can or grease gun. His practice can be devoted to control of the economic factors of plant operation, such as: (1) Quality, quantity and cost of lubricants used; (2) Duration of, and cost of time required to replenish lubricant, as consumed; (3) Expense of machine down-time for replacing worn parts due to improper lubrication; (4) Cost of new replacement parts necessitated by faulty lubrication; (5) Rate of production, as influenced by proper lubrication; (6) Waste and spoilage resulting from the manner of lubrication; (7) Power consumed by machinery in use; (8) Compensation costs resulting from accidents attributed to lubrication.

(Lubrication in the News, from 253)

proof performance. For further information write Lincoln Engineering Co., 5743 Natural Bridge Ave., St. Louis 20, Mo.

OIL-MIST LUBRICATORS with one-gallon or 12-ounce oil reservoirs and built-in automatic warning switches which signal the operator by horn and red light, or shut off the machine as the oil level becomes too low, have been announced by Alemite. For information write Alemite Div., Stewart-Warner Corp., Dept. P-102, 1826 Diversey Pkwy., Chicago 14, Ill.

PILOT BEARING BUSHING, providing a complete, lifetime seal against damaging grit and dust has been developed that offers greater accuracy than bearings placed directly in machines or die fixtures and offers greater bar support due to the overall length of the bushing. Exhaustive tests of the bushing have proven outstanding applications for steady rest and back-up rolls, internal centerless grinder pressure rolls, grit blasters, tumbling barrels, foundry equipment, road and farm equipment, heavy duty construction and well drilling equipment, and conveyor rolls. A specification catalog is available from J. G. Jergens Co., 1106 Avon Ave., Cleveland 5, Ohio.

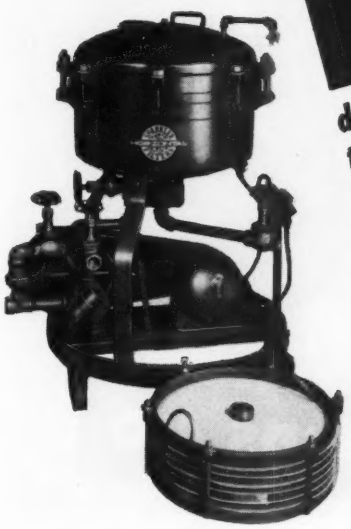
THE ELEKTRION PROCESS, Its History, Its Mechanism, Its Action on Lubricating Oils, by Michel Roegiers, is an abridged account of fifty years research work, the results of which were often deceptive but always instructive and sometimes triumphant, recently released by Societe des Huiles De Cavel & Roegiers, Coupure, 221, Ghent/Belgium.

VALVE SEAL A, a non-melting silicone lubricant for industrial use, has a combination of properties especially useful in pressure lubricated plug valves, automatic control valves, flow meter bear-

Keep your hydraulic oils, and coolants clean with . . .

SPARKLER FILTERS

designed specifically for this purpose. A practical protection for hydraulic machinery and cutting tools



The VR filter is designed for filtering hydraulic oil, quenching oils, transformer oil, solvents and other industrial liquids.

The Sumptype filter is ideal for filtering coolants. The filter plate assembly is attached to the intake pipe of the circulating pump and the coolant is drawn through the filter discs and delivered clean and free from all metal particles and grit, to the nozzels.

★ Clean hydraulic oil greatly prolongs the life of all moving parts, such as pistons, cylinders, pumps, valves, etc.

★ Filtering hydraulic oil extends the life of the oil. Drain and leakage oil may be reclaimed. One large user of hydraulic machinery saved $90,000.00 in hydraulic oil alone in one year by filtering oil with Sparkler Filters.

★ Filtering hydraulic oil eliminates sticking and clogging of valves and reduces down time and maintenance cost. A prominent authority on hydraulic machinery says that 70% of servicing and repairs is due to the improper condition of hydraulic oil.

★ Filtering coolant fluid removes all fine metal particles and grit from grinding wheels that is pumped back to nozzles unless a filter is employed in cleaning up the return coolant.

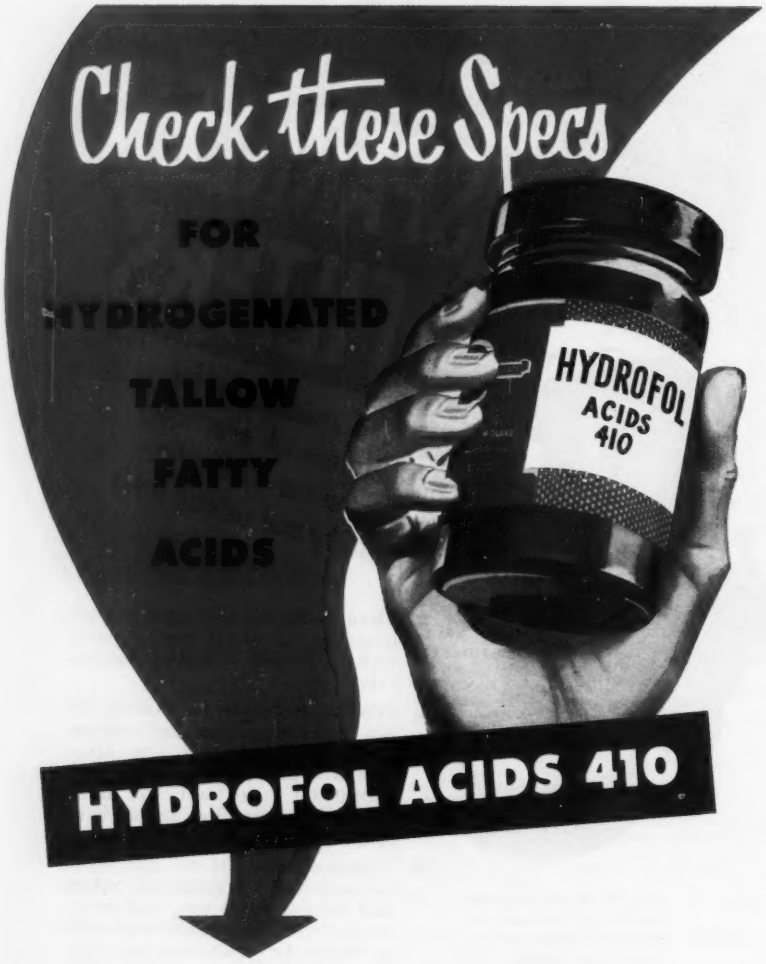
★ Clean filtered coolant prevents scratching and flat spots on work piece and increases the life of grinding wheels and cutting tools. Reduces the frequency of dressing grinding wheels.

The Sparkler VR filter is constructed on a simple filtering principle using filter paper as a media. The filter plates can be removed easily for cleaning which consists only of removing the dirty paper and replacing with fresh sheets. Any shopman can make this change of paper in a few minutes. The cost of replaced paper is less than a dollar per change.

Let a Sparkler representative demonstrate these filters in your plant

SPARKLER MANUFACTURING CO.
Mundelein, Ill.

REPRESENTATIVES IN ALL PRINCIPAL [illegible]



Iodine value	1.0 Max.
Acid number	201-206
Saponification number	202-207
Titre	58-61°C.
Color	White

This high-grade, white fatty acid is extremely stable against oxidation and rancidity . . . keeps its white color even at relatively high temperatures. Suitable for light-colored esters, candles, greases.

Try HYROFOL ACIDS 410 when making end products where color is important. Other hydrogenated tallow fatty acids in the HYROFOL series are HYROFOL ACIDS 400, 405, 420.

SAMPLES of each of these products, and prices, are available on request.

Hydrofol

ACIDS • GLYCERIDES • SPERM OILS • ALCOHOLS
FROM VEGETABLE • ANIMAL • MARINE OILS AND FATS

Produced In Any Quantity From SAMPLES TO SHIPLOADS

ARCHER • DANIELS • MIDLAND COMPANY
Chemical Products Division • 2191 West 110th St. • Cleveland 2, Ohio

ings, ceramic plug cocks and in pump packings. Physiologically inert and highly water repellent, it is resistant to oxidation and will not break down to form a carbonaceous or gummy deposit on valve surfaces. Technical Data Sheet VSA-1 covering data gathered during eight years of laboratry and field work with this material and including tables evaluating its performance in over 120 different chemical and gas services may be obtained by writing Dow Corning Corp., Midland, Mich.

WICK FEED OILERS, Style WOB, one piece hexagonal brass bodies and knurled brass screw tops machined from solid bar stock with wicks inserted into and around the standpipe for easy replacement or removal for stopping the oil flow, have been newly developed as a small capacity oiler feeding filtered oil through the wick over the standpipe to the bearing by capillary action assisted by a syphon effect. For further details write Oil-Rite Corp., 2328 Waldo Blvd., Manitowoc, Wis.

(Current Literature, from 254)

is no recognized U. S. standard for such instruments, other than those used in the Ford laboratories. It is recommended that for any data which are going to be compared in America and Britain, some other internationally accepted viscometric readings should be taken.

Vol. 15, No. 7, July, 1952, The Elektrion Process, Anon. Elektrionisation utilizes the silent electrical discharge ("glow discharge") to alter properties of lubricating oils or other materials. A detailed history of process is given, including its use around 1907 as a fish oil deodorizer, and later in production of "Elektrion Rape Oil" or "Elektrion Whale Oil." Effect of addittion of 10% Elektrion R, an "ultra-Electronised" pale viscous oil with a viscosity of about 200 centistoke at 100 C., containing no chemical additive, on SAE 20 and SAE 30 Mid-Continent solvent refined motor oils is shown in Table I. The effects of Elektrionisation on an oil are summarized as follows: increased viscosity, increased viscosity index, oiliness improvement, less resistance to sludge formation, lowering of Conradson Carbon test figures, development of "peptizing properties," pour point depressing, and color improvement. (No mention is made of voltolization or theVoltols.)

PETROLEUM ENGINEER, Vol. 24, No. 1, July, 1952, PAD Releases Results of Lubricating Oil Survey. Anon. Results of a survey of lubricating-oil production, including the chemicals used in that production, have been released by the Petroleum Administration for Defense. The survey was conducted in mid-1951 but tabulation of all details was not completed until the present. Information that was gathered in the survey and that is not classified for administrative or security reasons is set forth in six tables: 1. Refining capacity for production of lubricating oil in the continental United States classified by the viscosity index (V.I.) of the finished oil. 2. Refining capacity classified as "conventional" and solvent capacity. 3. Lubricating oil shipments from refineries, 1950 and first quarter 1951. 4 Refining capacity classified by the viscosity of the finished lubricant. 5. Wax production from the refining of lubricating oils, classified as crude unrefined wax, fully refined wax below 145 F., and fully refined wax above 145 F. 6. Chemicals used in the refining of lubricating oils.

PETROLEUM PROCESSING, Vol. 7, No. 7, July, 1952, Detergents From Petroleum, by F. D. Snell. This review covers properties and molecular structure of syndets (synthetic detergents) and advantages, disadvantages, and manufacture of alkyl aryl sulfonates and nonionic detergents. Some details and a flow diagram are included for the process for alkyl aryl sulfonate manufacture which involves steps: 1) sulfonation, 2) spent acid separation, 3) neutralization, 4) building, and 5) drying. A chart shows growth in surface-active agent production from some 50,000,000 lbs. of petroleum-based products in 1943 to about 370,000,000 lbs. in 1950.

PETROLEUM REFINER, Vol. 31, No. 6, June, 1952, Lube Oil Acid Treatment Developed for Italian Refineries, by F. Sager and F. Palmquist. Two-stage, centrifugal process offers advantage of higher yield and reduction in chemical consumption over the single-stage, according to the authors, who are with Separator-Nobel Co., Stockholm, Sweden. The principle of this process is as follows: through efficient mixing and a very short contact time, a selective action of the acid on the oil is obtained, in which physical extraction prevails over chemical reactions. The acid-oil mixture is then instantly separated. The spent acid from this stage is considerably more fluid than conventional acid sludge, and can be regenerated either separately or after blending with the secondary sludge. Simplified flow chart is shown.

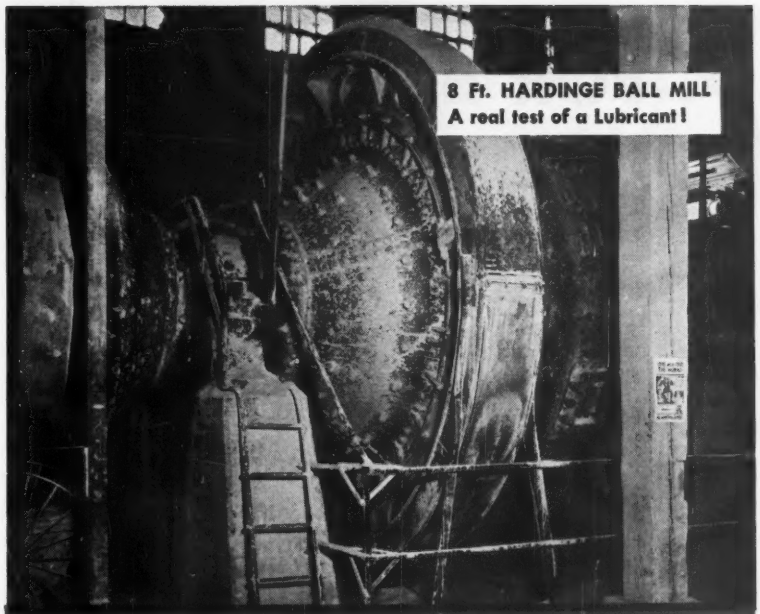
Vol. 31, No. 7, July, 1952, Stringent Specifications Met By Highly Refined Petroleum Oils, by G. Cibula. Highly refined petroleum oils must meet stringent specifications for resistance to deterioration by action with oxygen, acid, and alkalies. Herein discussed are the various types of "white oils" and the processes used in their manufacture. This article originally appeared in "Erdol and Kohle," Vol. 3, August, 1950, No. 8, where it was abstracted.

Viscosity-Temperature Dependence, by A. V. Brancker. A plot of viscosity versus viscosity over absolute temperature gives a straight line with slope "a" and intercept "b". In the region of the boiling point there is some deviation from the linear relationship, but not at low temperatures. At these lower temperatures the equation fits the data better than the function used for petroleum oils in the ASTM chart.

PETROLEUM TIMES, Vol. 56, No. 1431, June 13, 1952, Lubrication of Mule Spindles, Anon. The question of making compulsory the use of technical white oil for lubricating mule spindles, in view of the fact that this oil has been found to be free from the cancer-producing agent, was raised in Parliament (May 29). It was noted that it has not been confirmed that this oil is free from the cancer-producing agent.

Vol. 56, No. 1432, June 27, 1952, Progress in the Science and Art of Lubrication, by E. V. Paaterson. Discussed in this quarterly review of lubrication are the following topics: British Ministry of Defense Specifications DFF/2101, British Standards Institute draft specification for heavy-oils, the future of 5W oils, oil tests as engine condition indicators, use of chromium-plated aluminum cylinders, chromium-plated piston rings, Hi-Jet system of cooling oil application, oil content of soluble oils, development of synthetic lubricating oil for turbo-jet engines (MIL-L-7808), lubricating oil filtration, American Society of Lubrication Engineers annual meeting, and recent new lubricating oils.

Handling and Storage of Lubricants, Anon. The second booklet in the Vacuum Technical Series, entitled "Oil Storage Practice," is a detailed account of methods recommended for the handling and storage of lubricants in the works of the user. Copies may be obtained free of charge from the Vacuum Oil Co., Ltd., London.



"LUBRIPLATE No. 630-AA is practically a universal lubricant"

—so writes the Spokane Portland Cement Company of Irvin, Wash.

"**Lubriplate Lubricants** enabled us to cut the number of lubricants we were using to about half, but even then we were still using five different LUBRIPLATE Products. With the introduction of LUBRIPLATE No. 630-AA, we were able to reduce our requirements still further. Today we are satisfying all our needs for solid type lubricants with only two LUBRIPLATE Products. LUBRIPLATE No. 630-AA might almost be considered a Universal Lubricant. Furthermore, LUBRIPLATE No. 630-AA has effected a marked savings in lubricants and labor."

Frank D. Neill
General Superintendent

SIMPLIFY YOUR LUBRICATION SCHEDULE

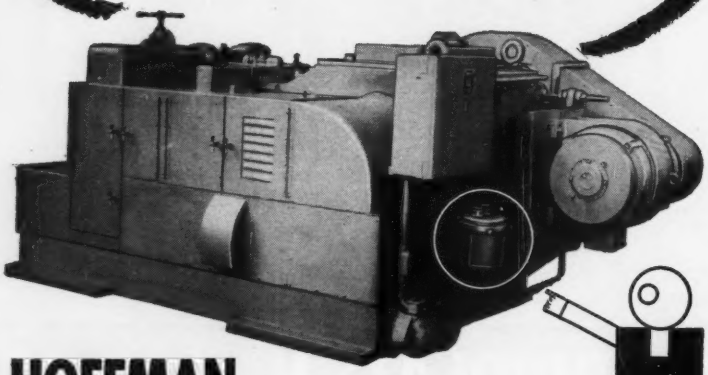
Lubriplate Lubricants set new high standards: They reduce friction, wear and power consumption. They prevent rust and corrosion of bearings, parts and product. They last longer than ordinary lubricants. LUBRIPLATE Lubricants are available from the lightest fluids to the heaviest density greases to meet all conditions, usual and unusual. Write for case histories of the use of LUBRIPLATE in your industry.

LUBRIPLATE DIVISION
Fiske Brothers Refining Company
Newark 5, N. J. Toledo 5, Ohio

DEALERS EVERYWHERE . . . CONSULT YOUR CLASSIFIED TELEPHONE BOOK

LUBRIPLATE *THE MODERN LUBRICANT*

FOR BETTER OIL CLARITY —MORE ECONOMY

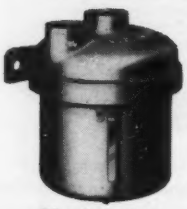


HOFFMAN DISC FILTERS NOW STANDARD on this Waterbury Farrel Hipro-Header

Despite a 10 to 1 difference in first cost, over previous filters, Hoffman Model I-6-15D Disc Filters proved more economical for Waterbury Farrel Foundry, builder of this high-speed Hipro Header.

Built to head bolts, screws, rivets, etc. from stock up to ⅜" O.D., this machine has a capacity of 115 units per minute. Extensive tests revealed that operation with the Hoffman filter meant greater lube oil clarity and longer filter disc life — thus, greater operating economy for the purchaser.

Hoffman disc filters have cleanable discs. Filtration at operating pressures up to 50 psi is accomplished without moving parts. Low maintenance cost. Write for Bulletin A669 for complete details *now*.



The I-6-15D

The I-4-15D

Hoffman Disc Filters, furnished in three sizes, may be installed singly or in units, to provide continuous clarification. Compact design for installation where space is limited. The I-4-15D delivers 1 to 10 g.p.m.; the I-6-15D provides 5-50 g.p.m. and the I-6-90D, 50 to 125 g.p.m. For the correct filter size for your requirement, Hoffman filtration engineers are at your service.

The I-6-90D

INDUSTRIAL FILTRATION DIVISION

U.S. HOFFMAN MACHINERY CORPORATION

216 LAMSON STREET, SYRACUSE 6, N. Y.

CANADIAN PLANT: CANADIAN HOFFMAN MACHINERY CO., LTD., NEWMARKET, ONT.

ASLE MEMBERSHIP CLASSIFICATIONS

Membership in the Society is in several grades as defined below. Assignment to grade is made by the Admissions Committee or Board of Directors on the basis of information submitted or supplied by references.

MEMBERS: Members shall be: (1) persons not less than twenty-four years in age who are engaged in research and instruction at technical schools, universities, and various publicly and privately supported institutions in the field of lubrication; or (2) persons not less than twenty-four years in age who have occupied recognized positions as lubrication engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibility for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) persons not less than twenty-four years in age who are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge, and accomplishment, have manifested a particular interest in the purposes and welfare of the Society, to the extent that their membership would be a valuable contribution to the successful functioning of its activities. Fee $12.50.

ASSOCIATE MEMBERS: Associate Members shall be persons less than twenty-four years in age, and those who do not completely fulfill the membership requirements for Members. Fee $6.25.

SECTIONAL SUSTAINING MEMBERS: Sectional Sustaining Members are such persons or organizations as may be interested in and desire to contribute to the support of the purposes and activities of a local Section of the Society. Fee $25.00.

INDUSTRIAL MEMBERS: Industrial Members are such persons or organizations as may be interested in and desire to contribute to supporting the purposes and activities of the Society. Fee $150.00.

FUNDAMENTALS OF LUBRICATION

Nine practical articles on the fundamentals of lubrication: Manufacture of Lubricating Oil, Lubricating Grease, Gear Oil Additives, Textile Spindles and Their Lubrication, Hydraulic Fluids Simplified, Oil Lubrication of Machine Tool Spindles, Dispensing Equipment, Steam Turbine Lubrication, Filtration of Industrial and Lubricating Oils. $1.00 per copy.

ASLE PUBLICATIONS
343 S. Dearborn St.
Chicago 4, Illinois

PHYSICAL PROPERTIES OF LUBRICANTS

(Second Edition)

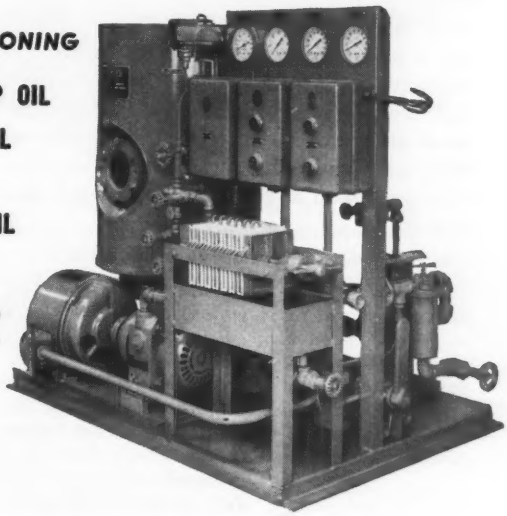
First in the series of ASLE monographs, covering Viscosity, Density and Specific Gravity, Cloud and Pour Points, Flash and Fire Points, Carbon Residue, Neutralization Number and Interfacial Tension, Saponification Number, Emulsification, Specific Heat. $1.00 per copy.

ASLE PUBLICATIONS
343 S. Dearborn St.
Chicago 4, Illinois

● DEHYDRATES
● DEGASIFIES
● STABILIZES
● CLEANS

IDEAL FOR CONDITIONING

- VACUUM PUMP OIL
- HYDRAULIC OIL
- LUBE OIL
- INSULATING OIL



Capacities from 45 to 500 g.p.h.

THIS Bowser dehydration system combines controlled heat, pressure-atomization, vacuum and micro-filtration to keep oil in tip-top condition. It's the best preventive maintenance insurance you can buy!

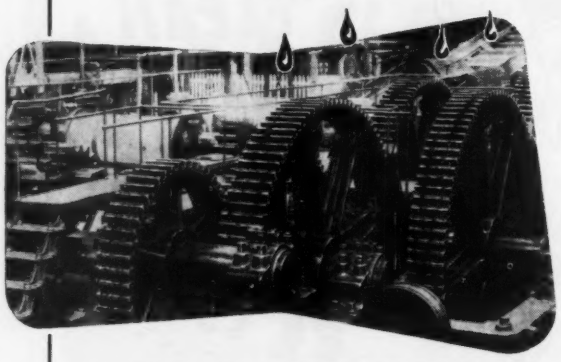
Write today for complete data.

BOWSER, INC., 1358 CREIGHTON AVENUE, FORT WAYNE 2, INDIANA

Regional Offices • Atlanta • Chicago • Cleveland • Dallas • Kansas City • Los Angeles • New York • San Francisco • Washington, D. C.

BOWSER — LIQUID CONTROL SPECIALISTS SINCE 1885

Lubricate OPEN GEARS



● FOR GREATER PROTECTION
● AT LOWER COST

with LEADOLENE* *Klingfast*

With its pH-ilm strength of 50,000 p.s.i., Klingfast is a lubricant for the toughest open gear applications. Whether severe water, abrasion, high heat or misalignment conditions are the cause of lubrication problems . . . Leadolene Klingfast, with its "Indestructible pH-ilm," provides the utmost in gear service and lubrication economy.

The following case history is significant:

"A motor-operated hoist equipped with double herringbone cut teeth pinions and gears is used to operate 5-ton clam shell buckets at a large coke plant. Although a high grade plastic compound was applied every 24 hours, it failed to prevent excessive wear of the gearing. On this application, which includes intermittent operation, reversing, high speed, severe shock and contamination from coal dust, Leadolene Klingfast is applied only once every 10 days, and costs 25% less per pound than the lubricant it replaced."

May we send additional details? Write for our new 24-page brochure.

*Leadolene—the "I.P. Lubricant" with Indestructible pH-ilm.

THE BROOKS OIL COMPANY

Executive Offices and Plant . . . . . CLEVELAND, OHIO
Executive Sales Offices . . . . . PITTSBURGH, PA.
Canadian Offices and Plant . . . . . HAMILTON, ONTARIO
Cuban Office . . . . . SANTIAGO de CUBA

Advertisers' Index

Acheson Colloids Co. 218
Alemite 259
Alpha Corp., The 258
Archer-Daniels-Midland Co. 268
Bowser, Inc. 271
Brooks Oil Co., The 272
Burns Laboratories, Inc. 260
Classified 246, 265
Climax Molybdenum Co. 266
Dow Corning Corp. 222
Farval Corp., The . . . . . (Inside Front Cover)
Frantz, S. G. Co., Inc. 262
Grafo Colloids Corp. 263
Hodson Corp., The . . . . . (Back Cover)
Honan-Crane Corp. 219
Houghton, E. F. & Co. 226
Ironsides Co. 227
Lubriplate Div., Fiske Bros. Refining Co. 269
Madison-Kipp Corp. 228
Manzel, Inc. 221
Morgan Construction Co. 225
Norgren, C. A. Co. 265
Oil-Rite Corp. 264
Penola Oil Co. 220
Shell Oil Co. 223
Sinclair Refining Co. 261
Sparkler Mfg. Co. 267
Stuart, D. A. Oil Co., Ltd. 217
Sun Oil Co. 229
Tide Water Assoc. Oil Co. 224
Trabon Engineering Corp. . . . . (Inside Front Cover)
Trico Fuse Mfg. Co. 260
U. S. Hoffman Machinery Corp. 270

Farval helps McKay handle tough plate leveling jobs

FLATTENING heavy steel plates is always a tough job. The rollers that do the leveling and the bearings on which they run are built to take plenty of punishment.

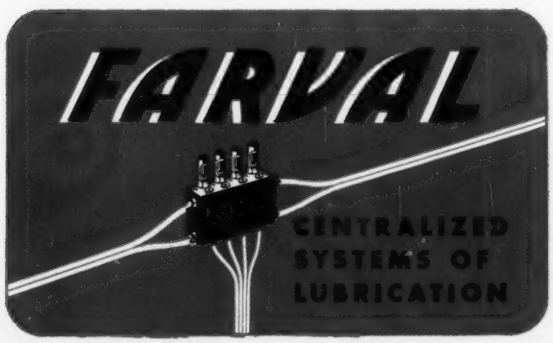
To keep all bearings on its levelers functioning smoothly and efficiently, McKay employs Farval Centralized Lubrication. In fact, Farval has been standard equipment for many years on all the roller levelers and many other types of machines this company manufactures.

Farval assures that every bearing regularly gets the exact, measured amount of lubricant it requires. Special oilers are not needed, lubricant consumption is reduced, bearing life is extended indefinitely and shutdowns for oiling or bearing replacement are eliminated. In short, with Farval on the job, the purchaser of a McKay leveler is insured of getting all the value built into the machine by its manufacturer.

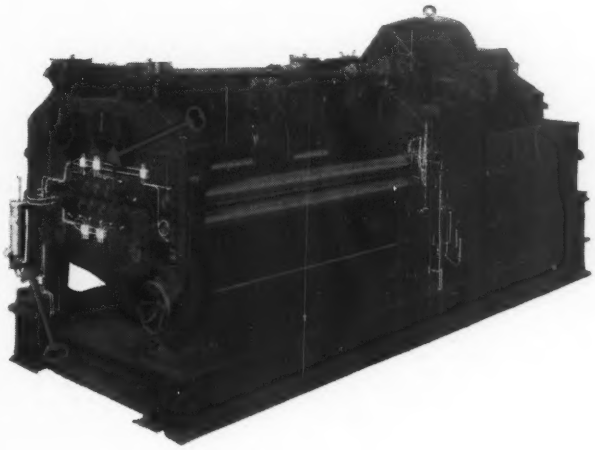
Farval is the original Dualine system of centralized lubrication for industrial equipment, proved practical in 25 years of service. The Farval valve has only two moving parts—is simple, sure and foolproof, without springs, ball-checks or pinhole ports to cause trouble. Through its full hydraulic operation, the Farval system unfailingly delivers oil or grease to each bearing—as much as you want, exactly measured—as often as desired. Indicators at all bearings show that each valve has functioned.

In or near your city there's a Farval engineer, ready to discuss your lubrication problems and suggest a proper system to meet your particular needs. The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm and Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



FARVAL—*Studies in Centralized Lubrication*
No. 129

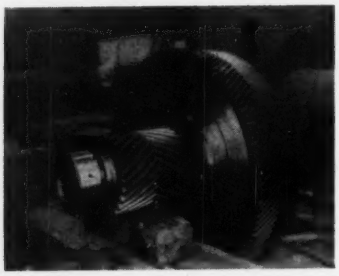


KEYS TO ADEQUATE LUBRICATION—*Whenever you see the sign of Farval—the familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated. Farval manually operated and automatic systems protect millions of industrial bearings.*

Photo above by courtesy of The McKay Machine Company.

HODSON'S

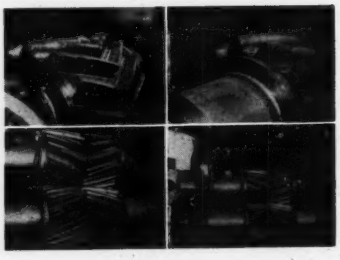
GEARKOTE ®



METALICOIL ®

DENSOIL

"FOUR HORSEMEN" PRODUCTS ®



METALICGREASE ®

PICTURES CANNOT TELL THE WHOLE STORY

• • • ASK FOR THE FACTS • • •

OUR FILES CONTAIN COMPLETE CASE
HISTORIES OF OUTSTANDING PERFORMANCE RECORDS
IN THE ROLLING MILL INDUSTRY

THE HODSON CORPORATION

Lubrication Engineers and Manufacturers

5301-11 WEST 66th STREET **CHICAGO 38, ILLINOIS**

Local Representatives

DETROIT, MICH.
PITTSBURGH, PA.

PHILADELPHIA, PA.
THREE RIVERS, QUEBEC

Printed in U.S.A.